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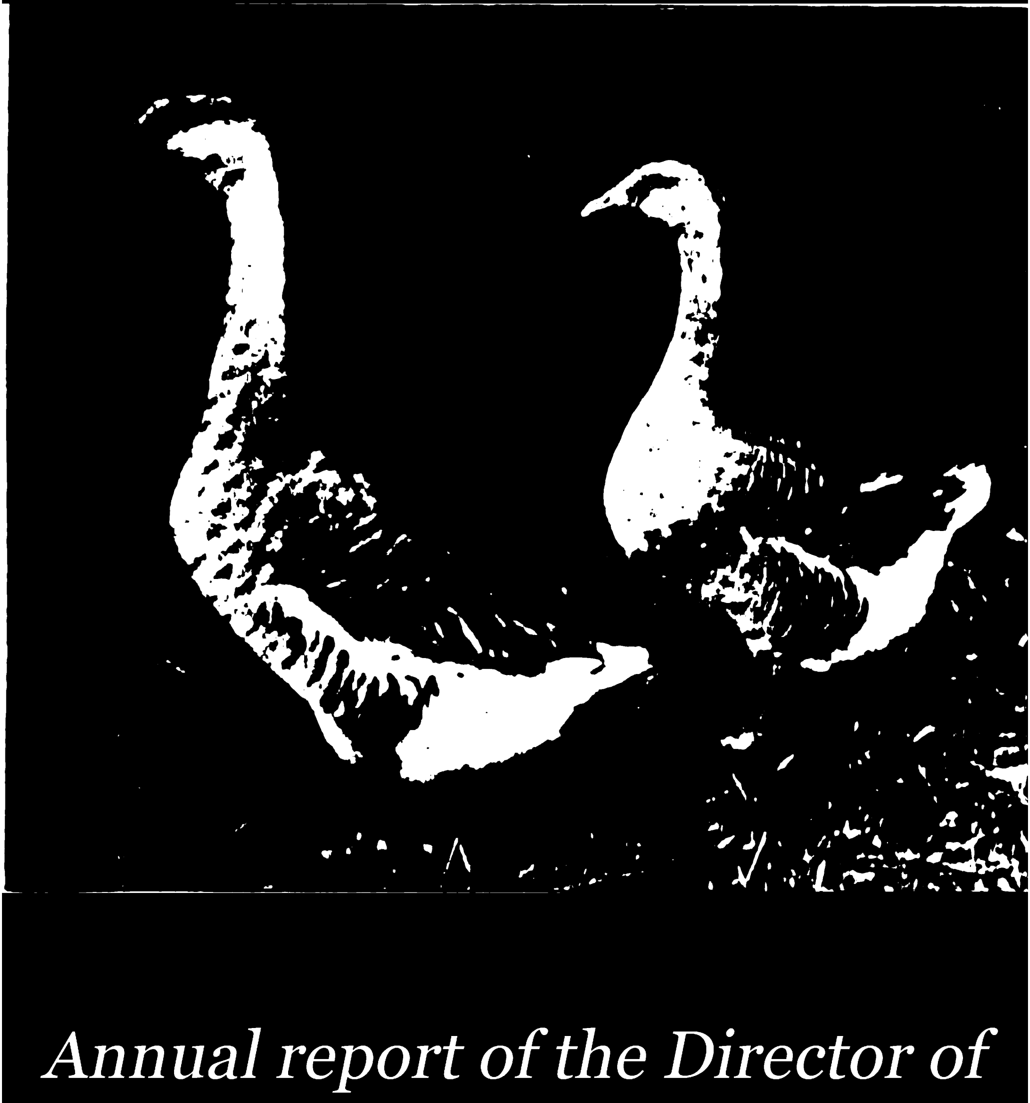
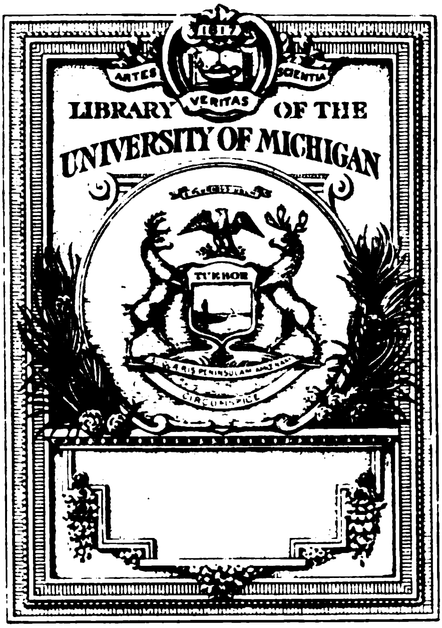


Annual report of the Director of the Agricultural Station ...

Rhode Island Agricultural Experiment Station



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1894.

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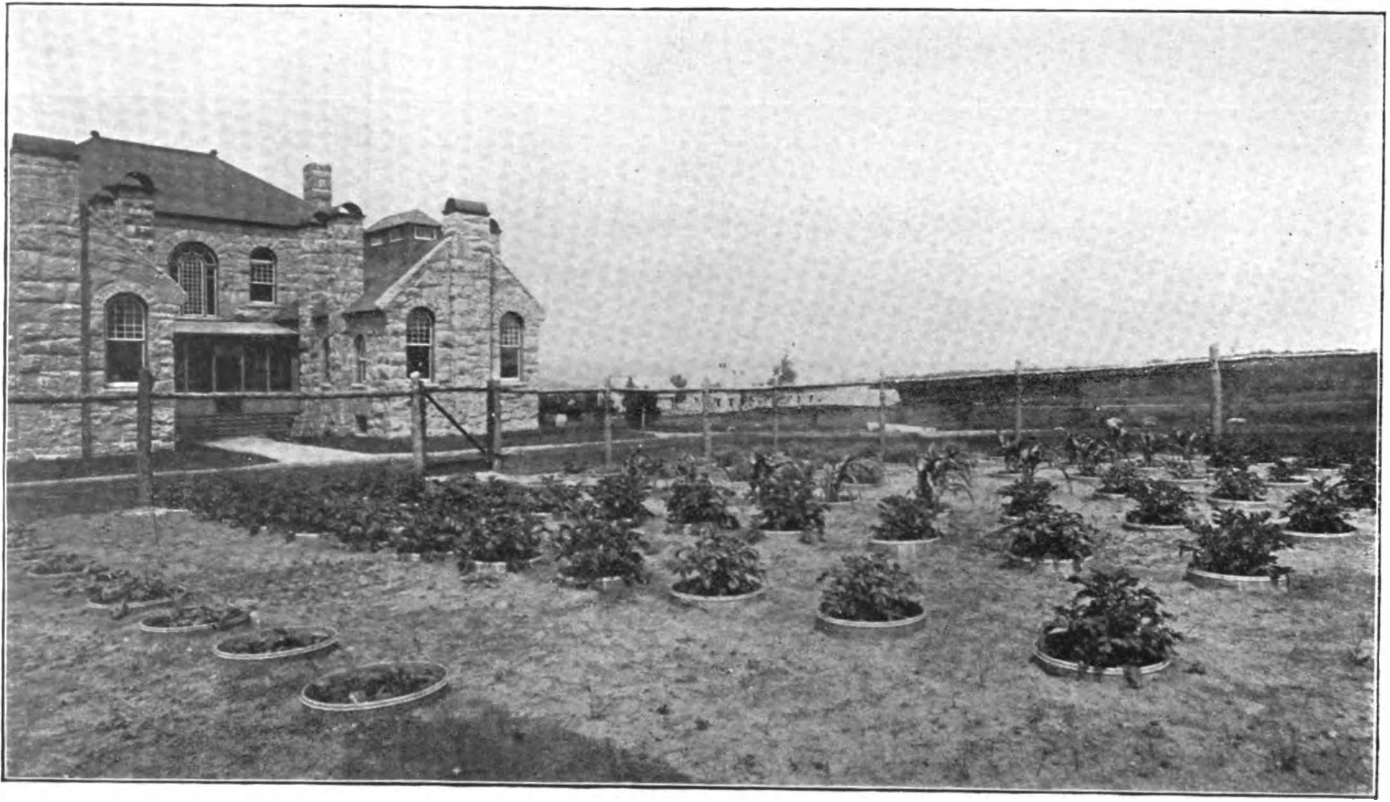

Pot Experiments.

State of Rhode Island and Providence Plantations.

SEVENTH ANNUAL REPORT

OF THE

RHODE ISLAND

AGRICULTURAL EXPERIMENT STATION, Kingsto

1894.

PART II.

OF THE

SEVENTH ANNUAL REPORT

OF THE

CORPORATION, BOARD OF MANAGERS,

OF THE

Rhode Island College of Agriculture and Mechanic Arts,

MADE TO THE

GENERAL ASSEMBLY AT ITS JANUARY SESSION, 1895.

[PART I. OF THIS REPORT — COLLEGE CATALOGUE — IS PRINTED UNDER SEPARATE COVER].

PROVIDENCE, R. I.
E. L. FREEMAN & SON, PRINTERS TO THE STATE.
1895.

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OF THE

RHODE ISLAND

COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

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J. D. Towar, B. Sc.,	First Assistant Agriculturist.
George M. Tucker, B. Sc.,	Second Assistant Agriculturist.
B. L. Hartwell, B. Sc.,	First Assistant Chemist.
Chas. L. Sargent, B. Sc.,	Second Assistant Chemist.
Nath'l Helme,	Meteorologist.
H. F. Adams,	Farmer.
Miss A. R. French,	Clerk.

The publications of the station will be mailed free "to such individuals actually engaged in farming as may request the same." The station desires the co-operation of the farmers of the State in the work of investigation, and any facts concerning unusual animal or vegetable growth or disease, are solicited. Visitors are always welcome. Railroad station, telegraph, express and post office, Kingston, Rhode Island.

General

LETTER OF TRANSMITTAL.

To His Excellency D. Russell Brown, Governor, and the Honorable the General Assembly of the State of Rhode Island, at its January Session, 1895:

KINGSTON, JANUARY 31ST.

I have the pleasure to present herewith, in compliance with the statute of the State and the Congressional act of March 2, 1887, the Report of the Director of the Rhode Island Experiment Station to John H. Washburn, President of the College, together with that portion of the Report of Hon. Melville Bull, Treasurer of the Board of Managers of the Rhode Island College of Agriculture and Mechanic Arts which relates exclusively to the Experiment Station.

Respectfully submitted,

For the Board of Managers,

C. H. COGGESHALL,

President.

REPORT OF THE DIRECTOR.

CHAS. O. FLAGG.

To J. H. Washburn, President:

In making the annual report I would first refer to additions and changes in the Station Staff, made last July. Mr. J. D. Towar, Assistant Agriculturist, was assigned the duty of Assistant Professor of Agriculture in the College and but a small portion of his time required by the Station. Mr. George M. Tucker, a graduate of the College, was appointed 2nd Assistant Agriculturist. In the Chemical Division increased work required the appointment of a 2nd Assistant, and Mr. Chas. L. Sargent, also a graduate of the class of '94, was selected for the position. The duties of the other members of the Station Staff remain the same as heretofore.

THE SEASON.

The average rainfall for the five years preceding 1894 was 54.51 inches. It ranged from 64.54 inches in 1889, which was a very rainy year, to 42.58 inches in 1892. The total rainfall for 1894 has been 48.19 inches, or 6.32 inches less than the average of the five previous years. The year was perhaps remarkable for extremes. The snow falls for the winter and spring months were exceptionally heavy, as a total of 75½ inches of snow fell during the year. The coldest day for thirteen years was in February. March was unusually mild and pleasant; frost was out of the ground and grass had started perceptibly by the end of the month. The middle of May was cold and exposed situations experienced a killing frost on the 15th. June was the dryest month in the seven years since observations were begun here, only ½ inch of rain falling. The weather was also very hot, the highest daily mean temperature for the year being 78°, recorded June 23d, while the mercury reached the highest point, 93°, June 17th and July 29th.

There was far less than the average percipitation during the nine months preceding October 1st, only 28.13 inches of rain and snow having fallen, an average of a little more than 3.12 inches, while the monthly average for the past six years, including 1894, is over 4.52 inches. The last three months of the year, however, made up much of the deficiency in precipitation during the previous nine months. October gave 9.14 inches, November, 5.26, and December, 5.66 inches, or 20.06 inches in the three months, equal to five-twelfths of the rainfall for the entire year.

The table shows the number of clear, fair, and cloudy days during the past five years, also the days when a hundredth of an inch or more of rain or melted snow fell.

	1894	1893	1892	1891	1890
Clear days	110	126	147	116	99
Fair "	130	130	116	154	143
Cloudy "	125	109	103	95	123
Rainy "	114	131	89	83	120

The effect of the drouth upon the cultivated crops in the State was inevitable. The hay crop did not suffer materially as the full effect of the drouth was not apparent until later in the season. Pastures became very dry and feed short. Potatoes and corn suffered to some extent, and small fruits were injured.

CHEMICAL DIVISION.

Eighty-one samples of complete fertilizer, i. e., those containing nitrogen, phosphoric acid and potash, and twenty-seven samples of agricultural chemicals and wood ashes have been collected and analyzed under the State Fertilizer Inspection Law. The analyses have been published in Bulletins Numbers 28, 29, and 30, and a tabulated report furnished to the State Board of Agriculture, as required by law. The quality of the fertilizers is better than last year, and the average price per ton has steadily decreased since 1891. The following summary is from page 65 of Bulletin No. 30:—

AVERAGE SELLING PRICE AND VALUATION OF COMPLETE COMMERCIAL FERTILIZERS FOR 1891–94.

	1891	1892	1893	1894
No. of brands*	58	81	74	75
Selling price per ton	$36.64	$35.80	$35.79	$33.57
Commercial valuation per ton	27.03	26.37	23.79	23.51
Average difference	9.61	9.43	12.00	10.06

Percentage relation between the fertilizing constituents found and their guaranties for 1891–94:

	1891 Per cent.	1892 Per cent.	1893 Per cent.	1894 Per cent.
Equal to or above the guaranty	71.06	80.71	75.74	80.89
Less than .3 per cent. below the guaranty	10.64	9.00	13.77	7.97
More than .3 per cent. below the guaranty	18.30	10.29	10.49	11.14

The fertilizing materials used in experimental work on the station farm have been analyzed, and analyses made of samples of home-mixed fertilizers and fertilizing materials sent in by farmers. The moisture has been determined in numerous samples of experimental crops and many specimens of soil tested for acidity. Considerable work has also been done in the "methods of potash determination in connection with the Association of Official Agricultural Chemists."

The plan of pot experiments commenced last year was continued this season on an enlarged scale. Last year twenty-eight galvanized iron cans, each eighteen inches in diameter and twenty-six inches deep, were used. This year sixty-six were added and the scope of the work enlarged. Reference to the report of the chemist is made for further details. The frontispiece of the report is a good illustration of the ground and enclosure devoted to pot experiments. The field experiments conducted by the Chemical and Agricultural Divisions have furnished valuable results already, with promise of more light upon some obscure problems of agriculture. Details of work and some results with illustrations of crops produced may be found in subsequent pages of this report.

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* Brands not sold in ton quantities and those concerning which data necessary in making this statement was lacking have been omitted.

HORTICULTURAL DIVISION.

The orchard and trial grounds have been thoroughly fertilized with stable manure, seaweed and chemicals so that the growth of trees and small fruits has been quite satisfactory. A portion of the orchard has been seeded to grass as it was not desirable to cultivate so large an area, the remainder, except land devoted to small fruits, seedling trees and trial grounds, is used for the production of vegetables for the College Boarding Hall, under the direction of the Horticulturist and an assistant apppointed by the College.

A limited number of small fruit plants of some of the more reliable new kinds were distributed by mail to persons in the State who requested them and remitted twenty-five cents to cover cost of packing and mailing. Packages of plants were sent to 163 persons who thus applied for them. The field experimental work has been mainly in the line of the prevention of the various fungous diseases of the foliage and fruit of pears, apples and quinces. The study of the apple rots has been continued in the laboratory.

POULTRY DIVISION.

The crossing of Toulouse and Embden geese has been the principal work of the Division, although some cross bred fowls were reared in continuation of previous work. The goose rearing industry is one of hardly less importance than the raising of turkeys in Rhode Island, yet comparatively few are well informed regarding it. The opportunities for the development of the industry are great owing to the extended coast line and numerous streams and ponds. The goose is very hardy and of quick growth, easily and cheaply fed as compared with other fowl, and far less often found on the table of our citizens than it would be were the fine quality of well-bred birds better known. No young turkeys were bred on the farm owing to the liability of damage to growing experimental crops through their roving habits.

BLACK HEAD OF TURKEYS.

Parts of turkeys sick or having died with the, so-called, "Black Head" were sent last year to Dr. Theobald Smith, Chief of the Division of Animal Pathology, Department of Agriculture, Washington, D. C., for examination. The results pointed toward a disease different in origin and description from any heretofore known, and arrangements were made with Dr. Smith to come to this Station for a short time for further study of the disease. A circular bulletin was issued in July requesting information as to outbreaks of the disease, and specimens of sick or dead birds for examination. Some of the large flocks of turkeys in this county were inspected, and with some birds kindly sent in by express plenty of material was found for study. Some few cases of "gape worms," more of "tape worms," and most of the remainder true cases of the disease we call "Black Head," for want of a better name, were found. Dr. Smith finds the disease probably due to the presence of a protozoa which produces a diseased condition of the liver and the cæca, or that portion of the intestine forming two pockets or branches. The results of his examinations will be published by the Department of Agriculture, but further study is necessary to determine the life history of this protozoa and find a remedy for the disease. We feel under great obligation to Dr. Smith and the Department of Agriculture for the investigation thus far and only hope that the work may be speedily continued by them to a successful issue.

For two years the head of this Division has been allowed by the Board of Managers to serve as Secretary of the Rhode Island Poultry Association for the benefit of the poultry interests of the State. The influence of a Poultry Society and its exhibitions well supported and rightly managed cannot but be beneficial. The duties of the Secretary of the Poultry Society, however, demand a large amount of time and detail work which experience has shown necessarily interferes with Station duties to such an extent as to render the duties of the two positions somewhat incompatible. While every effort will be made to encourage our poultry industry, justice to the work of the Station as well as the poultry interests of the State, requires time for the active prosecution and prompt publication of the results of experimental work.

AGRICULTURAL DIVISION.

The following is an outline of experimental field and pot work carried on in connection with the Chemical Division:

Field and pot experiments showing the action of air-slacked lime when used in connection with nitrogen in the following forms: "Pennsylvania tankage," dried blood, sulphate of ammonia and nitrate of soda. Potatoes were employed in the field experiment, part of the seed tubers being treated with corrosive sublimate and part remaining untreated for the purpose of determining the effect of the treatment and lime upon the development of the potato "scab." Oats were employed in the pot experiments.

Field experiment with oats showing the use of air-slacked lime in overcoming the ill effect of sulphate of ammonia by which it becomes a valuable fertilizer, also its effect when used in connection with nitrate of soda and dried blood. This experiment also shows the relative value of nitrogen in different forms when used on a practically neutral and on an acid soil.

Soil test with fertilizers for the purpose of ascertaining of what element the soil is chiefly in need. In this experiment about thirty different kinds of plants were employed for the purpose of ascertaining if the results secured with the various plants are identical.

Experiment with seventy different kinds of plants showing the value of air-slacked lime in overcoming the ill effect of sulphate of ammonia, by which its nitrogen is also rendered available to plants. This experiment furnished a good opportunity to study the effect of sourness or acidity of soils upon the growth of the various plants and the value of lime as a corrective.

Pot experiments with beets and spinach testing the value of *various alkalies* in overcoming the acidity of the soil and their influence upon the growth of the plants.

Experiment in pots with Indian corn testing the value of *various alkalies* in overcoming the ill effect of and in rendering available the nitrogen of sulphate of ammonia.

Experiments in pots with potatoes to determine the effect of different compounds of lime and also barnyard manure (under various conditions) upon the development of potato "scab."

Experiments in the field for the purpose of ascertaining if soda has any value as a fertilizer when used alone and in connection with potash.

The following were the more important of the additional experiments carried on:

Experiment with thirty of the nitrogen gathering or leguminous plants to ascertain if any of them will flourish without any nitrogen or if a small dressing is desirable or necessary.

Tests of six different rotations of crops continued on twenty-eight one-tenth acre plots.

Tests to determine the most economical form and kind of phosphoric acid used with and without lime in connection with Indian corn. Eight forms including both "raw" and "super" phosphates were used.

Test of fodder plants including Lathyrus sylvestris or "Flat Pea" and alfalfa.

Test of varieties of potatoes in quantities varying from one pound to one peck.

Test of the budding process with seed potato tubers for hastening the time of maturity of the crop.

Trial of the growth of a crop of potatoes upon a clover sod. One-half the field was limed when the clover was sown, and consequently produced a far heavier growth of clover than the other; the yield of potatoes, however, varied little.

FIELD CROPS.

The following is the approximate quantity of field crops produced: Hay suffered somewhat from the drouth, and the yield was a trifle less than last year—about 20 tons, rye straw 2 tons, oat straw 6 tons, corn stover 12 tons. Thirty bushels of rye were threshed, and 270 bushels of oats. Five and a half acres field corn were planted in addition to experimental plots, and the total yield was 800 baskets of ears. A tenth of an acre of Hubbard squashes produced 3,000 pounds. Other crops were 420 bushels of potatoes, 300 bushels of carrots, and 80 of turnips.

OATS.

Four and one-half acres of land at the west end of the farm were seeded to grass with rye, in the fall of 1890, but made a poor catch. This piece was plowed early in the spring and dressed with air-slacked lime, at the rate of 1,760 pounds per acre, and a home mixed fertilizer, composed of 100 pounds of nitrate of soda, 100 pounds of tankage, 200 pounds dissolved South Carolina rock, 200 pounds of fine ground bone, and 200 pounds of muriate of potash per acre was applied broadcast with the "Spangler" Lime Spreader, and thoroughly harrowed in. The oats were sown broadcast, three bushels per acre, and about twenty pounds of red clover seed. After seeding the field was rolled. At the seeding in 1890 clover made a very poor catch taking the field as a whole. Sections which had been dressed with stable manure or seaweed produced a fair growth, but other sections dressed with chemicals alone produced very little grass and no clover. The effect of air-lacked lime upon the growth of clover on other portions of our plain land led to the application of lime at this time in connection with clover seed for the purpose of securing a good stand of clover with the expectation that the quality of the soil would improve through the addition of organic matter and nitrogen in the large growth of roots and stubble. The grain and clover seed germinated well and both made an excellent growth—the clover making a very even catch, quite unlike the previous seeding. Quite a thick growth of "wild mustard" (*Brassica sinapistrum*) appeared in June, as it does everywhere on the farm fields seeded to grain, and necessarily interfered with the growth of the crop. Considerable brown "rust" appeared upon the oats, and the extreme drouth parched the ground and for a time entirely stopped the growth of the clover. After the oats were harvested the clover revived with the coming of the fall rains, and the mowing machine was once run over the field with the knife well set up to clip off all weeds and clover heads, which were allowed to lie on the ground for mulch. 120 bushels of oats were threshed from the field.

OAT SMUT.

In 1892 and 1893 the seed oats sown on the farm were treated with the "Jensen hot water treatment"* for the destruction of the germs of the "loose smut" of oats, *Ustilago avenæ* (Pers) Jensen. The treatment was thoroughly effectual, no "smut" being found in the crop either while growing or at harvest. In 1894 the oats sown were the product of the seed treated in 1893, and no "smut" was found in the crop, although plenty of it was noticeable in some trial plots of seed oats obtained from outside sources. The "Jensen hot water treatment" will effectually destroy all germs of smut and is cheap and safe. The Vermont Experiment Station has shown by an examination of samples from 82 fields, that Vermont seed oats produce but about one per cent. of smutted heads,* while "Western" seed oats produce 3.13 per cent. of smutted heads. The loss from "oat smut" is estimated by the U. S. Department of Agriculture to vary from 5 to 12 per cent. in various parts of the country, and some large oat-growing States put the average loss at ten or more per cent.

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* See Bulletin No. 15 and Fifth Annual Report, p. 183.

SEEDING TO GRASS.

Besides the field seeded to oats and clover already mentioned above, five acres on the hill east of the College buildings, which have been gradually reclaimed from a rough, bushy pasture, and a portion of the stones removed, were plowed, fertilized, and sown to oats and clover seed. About one acre near the Mechanical Building was also seeded to grass. In July a field of two and one-half acres, which was sown to clover seed in 1893, and one-half of which was dressed lightly with air-slacked lime, (one-half ton per acre) was plowed, and the growth of clover and sorrel upon it turned under. Where no lime was put there was only an occasional clover plant, the ground being entirely occupied with sorrel. On the north half of the field there was about half a stand of clover, showing that the lime applied had been a benefit although insufficient in quantity for the best results upon such acid land. The field was harrowed at intervals sufficiently often to prevent the growth of sorrel and weeds until September when

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† Seventh Annual Report, Vermont Agricultural Experiment Station, 1893, p. 61.

it was fitted for seeding. At this time four and one-fifth tons of air-slacked lime was applied broadcast and thoroughly worked in. Timothy, red top, and clover seed were sown and a good fall growth followed. Four and one-half acres north of the orchard, where field corn was grown, was plowed and seeded after the corn was harvested, also two acres of plain land, where potatoes were grown, was sown to winter rye and grass seed.

FARM STOCK.

The live stock at present owned by the Experiment Station is as follows:—

One pair chestnut work horses, one pair gray work horses, one driving and general purpose horse, one Ayrshire bull—2 years old, one Ayrshire cow, three Holstein cows, one grade Guernsey cow, one grade Ayrshire cow, one native cow, three heifer calves, one Berkshire boar, two Berkshire sows, two grade sows, seven shoats.

The Holstein, Ayrshire and Berkshire stock is pure, and recorded in the Herd Registers. In addition to the above the College owns one driving horse and one work horse.

AGRICULTURAL FAIRS.

An exhibit illustrating some of the work at the Station was made at the Washington County Fair and also at the State Fair at Cranston. It included a large collection of the newer varieties of potatoes with yields per acre. An interesting collection of potatoes grown upon plots of limed and unlimed land, illustrated the increase of yield by liming and at the same time the greater development of "scab" on the crop grown upon the limed land. Beets were also exhibited grown upon land infested with the germs of potato scab under the same conditions as to liming and disfigured by the same disease. The different cereals grown upon the same plots of limed and unlimed land were exhibited, illustrating the marked increase in the crop upon our plain land through the use of air-slacked lime. The Horticultural Division prepared a collection of the materials used as fungicides and insecticides, ready for application, also a collection of the parasitic fungi attacking fruits in the State. A collection of fruits was shown, illustrating the advantage of spraying apples, pears, and quinces to destroy insect enemies and fungous diseases.

The Poultry Division exhibited various crosses of Aseel with White Wyandottes and other fowls, also ten pens of different pure-bred and cross-bred geese. A collection of jars and cuts was shown illustrating the "gape worm," tape worms of turkeys, and the liver and cæca of turkeys with "Black Head" in a severe form.

PHOTOGRAPHS.

Hon. Rowland Hazard, the President of the Washington County Agricultural Society, has for some years on the occasion of his annual address before the Society presented the members with some interesting and valuable information or statistics compiled and published under his direction. Having visited the Experiment Station several times and seen the results obtained by the use of air-slacked lime in connection with fertilizing materials, as illustrated in the field by the growth of crops, he requested permission to publish a series of photographs which were being prepared for our Annual Report, to which we heartily assented. Half-tone copies were printed and tastefully bound in a 62 page pamphlet, under the title of "Photographs of the Results of Experiments Conducted at the Rhode Island Agricultural Experiment Station, 1893. Selected by permission from the forthcoming report of the Experiment Station, and presented to the Washington County Agricultural Society at its Twentieth Fair, by Rowland Hazard, President of the Society."

PUBLICATIONS.

Four Bulletins have been issued during the year, in editions of 5,000 and 5,500 copies, but very few of which now remain on hand.

The demand for our publications is constantly increasing, mainly through personal application on the part of visitors or by letter or postal card. Many of the numbers issued in previous years are now sent only to Public Libraries or Experiment Stations where complete sets of our publications are desired for public use. The postal law now permits postmasters to return all bulletins and reports in our franked envelopes which fail to find the person addressed. The return of undelivered copies helps us to keep our list corrected. Occasionally we may be obliged to attach a slip to some issue requesting a reply if further numbers of our publications are desired. These are the only means we have for correcting our mailing list. We desire to have our publications reach all who are interested in, and may be benfited by, our work.

Including this Report, ending with 1894, 30 Bulletins and 7 Annual Reports have been published. The Bulletins are numbered consecutively from 1 to 30, and the Annual Reports are styled, First, Second, Third, Fourth, Fifth, Sixth, and Seventh.

The following Bulletins have been published during the year :—

No. 27. Leaf Blight of the Pear. Raspberries; Distribution of Plants. March. 12 pp. 9 cuts.—L. F. Kinney.

No. 28. Rhode Island Soils. Fertilizers. July. 30 pp.—H. J. Wheeler and B. L. Hartwell.

No. 29. Fertilizers; Commercial and Special Formula. October. 14 pp.—H. J. Wheeler and B. L. Hartwell.

No. 30. Fertilizers. Potato Scab. November. 30 pp. 19 cuts.—H. J. Wheeler, J. D. Towar, and G. M. Tucker.

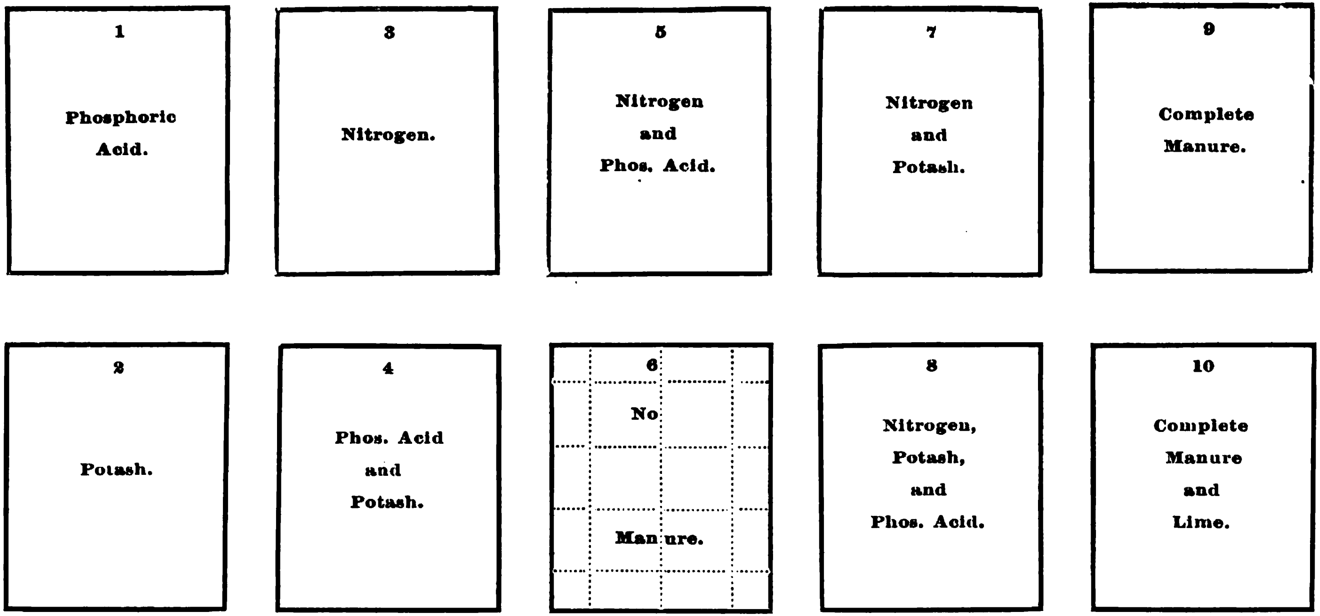
CIRCULAR BULLETINS.

A new departure was made by the publication in February of a "Circular Bulletin No. 1," covering but four pages, which was folded and mailed in common envelopes. The subject was a plan for a soil test with fertilizers for the farmer to pursue on his own land, and as the subject is of general interest now as much as at that time it is reproduced here with some additions.

The knowledge of the fertilizing element or elements to apply upon a certain field, that the very best results may be obtained at the least cost, is greatly desired by every tiller of the soil. Chemists everywhere agree that a chemical analysis of the soil (virgin soil excepted) will not give the desired information for various reasons, chief of which is that plants take their food in extremely weak and dilute solutions, and much plant food found by *artificial chemical* methods is not directly available for the support of plants. Many years of exposure to nature's processes are required in order to make it soluble. How, then, can the farmer best determine what elements to apply to his exhausted fields? A careful trial of the various fertilizing elements separately and combined in various proportions upon the soil in question commends itself to the careful observer. By this means the question of what is lacking is put directly to the soil, and the crop produced is a more or less definite answer according to the thoroughness and care exercised in the trial.

The size of the piece required for the ten (10) plots and the paths which separate them is 25 x 57 feet, the paths each 3 feet in width. The spot selected should be as even in quality of soil and fertility as possible, and the nearer level the better. The experiment will be of most value if corn is planted one year, potatoes next, followed with rye and grass, or oats and clover the third, each plot receiving a dressing of the same kind of fertilizer each year. Potatoes can be grown for the first crop, however, if any one desires. The corners of the plots should be marked with stakes well driven in the ground, and if the trial is continued more than one season the plots should be *spaded* the second and third years, rather than plowed. The fertilizer for each plot should be carefully and evenly spread upon the surface, taking care that it is not blown about by the wind. (If the wind is strong take two or three quarts of soil from the plot to be sown and mix the soil and fertilizer well together, after which it can be sown without danger of loss by the wind or contamination of other plots.) The fertilizer should be thoroughly incorporated with the soil by raking or digging.

CORN.



Plots are 9 x 11 feet = 1-440 of an acre; paths 3 feet, with 3 foot space outside of all plots. Plant corn in hills 3 x 2¾ feet (12 hills on each plot) and thin to four stalks in a hill. (See dotted lines on No. 6.) Keep free from weeds by hand cultivation. A horse may be used in the paths.

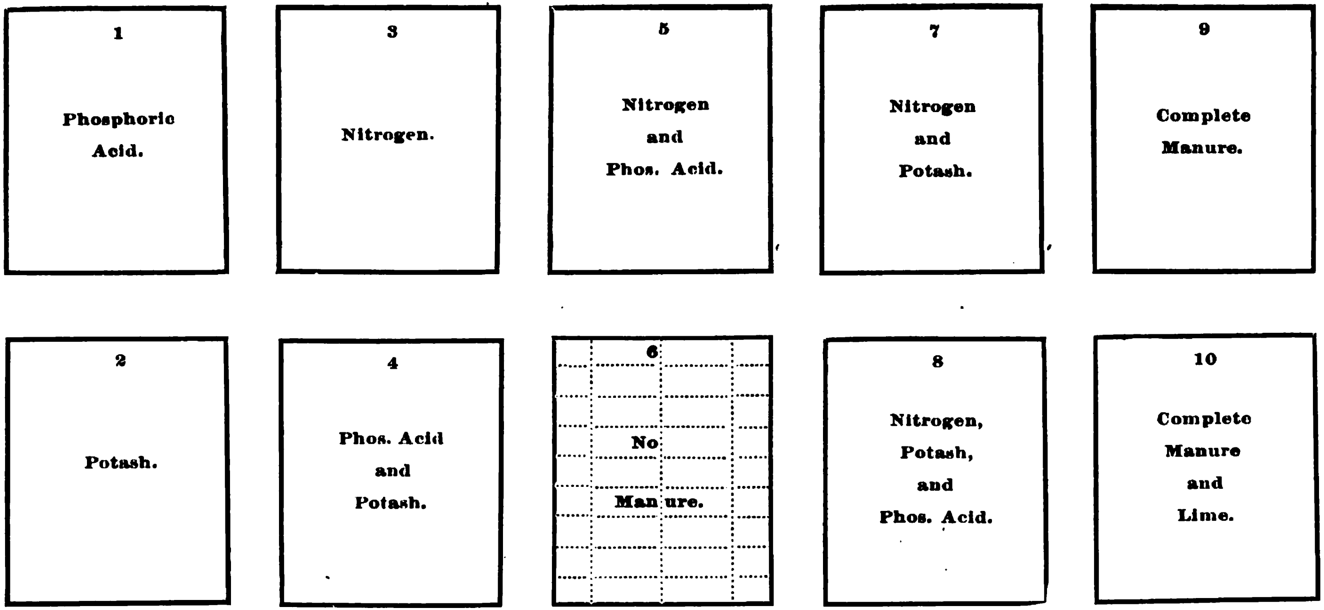
CORN.

Plot.	Kind of Fertilizer.	Lbs. Per Plot.	Lbs. Per Acre.
1	Dissolved South Carolina Rock	1.75	770
2	Muriate of Potash	0.50	220
3.	Nitrate of Soda	1.10	484
4.	Dissolved South Carolina Rock	1.75	770
	Muriate of Potash	0.50	220
5.	Dissolved South Carolina Rock	1.75	770
	Nitrate of Soda	1.10	484
6.	No Manure	....	...
7.	Muriate of Potash	0.50	220
	Nitrate of Soda	1.10	484
8.	Nitrate of Soda	1.10	484
	Dissolved South Carolina Rock	1.75	770
	Muriate of Potash	0.50	220
9.	Nitrate of Soda	0.375	165
	Dried Blood	0.55	242
	Sulphate of Ammonia	0.30	132
	Muriate of Potash	0.50	220
	Dissolved South Carolina Rock	1.75	770
10	Same as No. 9	3.475	1529
	Plus Air Slacked Lime	11.364	5000

POTATOES.

Plot.	Kind of Fertilizer.	Lbs. Per Plot.	Lbs. Per Acre.
1.	Dissolved South Carolina Rock	1.75	770
2.	Muriate of Potash	0.75	330
3.	Nitrate of Soda	0.50	220
	Dried Blood	0.85	374
4.	Dissolved South Carolina Rock	1.75	770
	Muriate of Potash	0.75	330
5.	Nitrogen, same as No. 3	1.35	594
	Dissolved South Carolina Rock	1.75	770
6	No Manure	....	...
7.	Muriate of Potash	0.75	330
	Nitrogen, same as No. 3	1.35	594
8.	Nitrogen, same as No. 3	1.35	594
	Muriate of Potash	0.75	330
	Dissolved South Carolina Rock	1.75	770
9.	Nitrate of Soda	0.375	165
	Dried Blood	0.55	242
	Sulphate of Ammonia	0.30	132
	Muriate of Potash	0.75	330
	Dissolved South Carolina Rock	1.75	770
10.	Same as No. 9	3.725	1639
	Plus Air Slacked Lime	11.364	5000

POTATOES.



Plots and paths the same as in the Corn experiment. Plant potatoes cut in two-eye pieces the size of a pullet's egg, in drills, lengthwise of the plots; use only one piece to the hill, making twenty-four hills to the plot, 36 x 16⅛ inches apart. (See dotted lines on No. 6.) Keep free from weeds by hand cultivation. A horse may be used in the paths.

SEEDS.

On the fourth page of Circular Bulletin No. 1 it was stated that "The Department of Agriculture at Washington desires the address of a limited number of farmers who will *receive*, *test*, and *report* upon the value of certain field and garden seeds for cultivation in this State."

The application and the report were to be sent to the Experiment Station and forwarded by us to Washington — the seeds being sent by the Department directly to the applicant. Seventy-seven applications were received and forwarded to Washington. Seeds were sent to thirty-two persons, but in some instances too late for trial, and some only received a small part of the seeds asked for. Reports were in most instances very meagre and incomplete for the above reasons. Twenty-one persons reported to us, and the reports have been forwarded to Washington.

Circular Bulletin No. 2, 2 pp., was issued July 15th by the Poultry Division, and was in relation to the disease of turkeys locally known as "Black Head." Notice was given in it of the contemplated investigation at this Station of the disease by Dr. Theobald Smith of the Division of Animal Pathology at Washington, and any information relative to the disease or any specimens of sick or dead turkeys solicited.

Circular Bulletin No. 3, 4 pp., was issued at the same time and contained a brief outline of the experiments and work at the Station and in other places under the direction of the Station.

CORRESPONDENCE.

The volume of correspondence in all divisions of the Station has increased rapidly during the year. Many inquiries relative to various farm operations are received, and as far as possible the information desired is furnished. Inquiries in regard to the use of fertilizers, the compounding of special mixtures for particular crops or fields, and the use of agricultural chemicals and lime are perhaps the most numerous, but information regarding fungicides and insecticides as well as the various phases of poultry management is also frequently solicited. Letters which record success attained in the various methods of fighting insect and fungous enemies and the growing of larger or better crops through more rational fertilization are not infrequently received, all of which we think an indication of more thought and care in the prosecution of agriculture, and without which the highest success cannot be attained.

In conclusion we would thank all our co-workers for the interest and efficient service which has been manifested in the work of the year.

FIELD EXPERIMENTS.

CHAS. O. FLAGG, J. D. TOWAR, AND GEO. M. TUCKER.

THE USE OF LIME FOR OATS.

The plots used in this experiment were the one-twentieth acre co-operative plots which had grown corn the previous four years.*

These plots were ploughed, harrowed, and oats sown at the rate of about three bushels per acre on the 9th of April. The oats germinated well, and those on the limed sections grew rapidly and were a rich green in color, while those on the unlimed sections were yellow and sickly in appearance and unthrifty and spindling in growth; the color improved as the weather grew warmer, but they failed to "stool" and the crop was thin. On July 12th, before the grain was mature, the entire crop was cut and weighed, to be afterwards cured as hay. The weights were taken as soon as the oats were cut, that being thought the best time at which a just comparison could be made, the crop being so unequal in growth as to render it almost impossible to cure it so as to get an equal degree of dryness; the weights in a fresh state are, therefore, given in the table. At this time the oats were so rank and thick on some of the limed sections that they had lodged.

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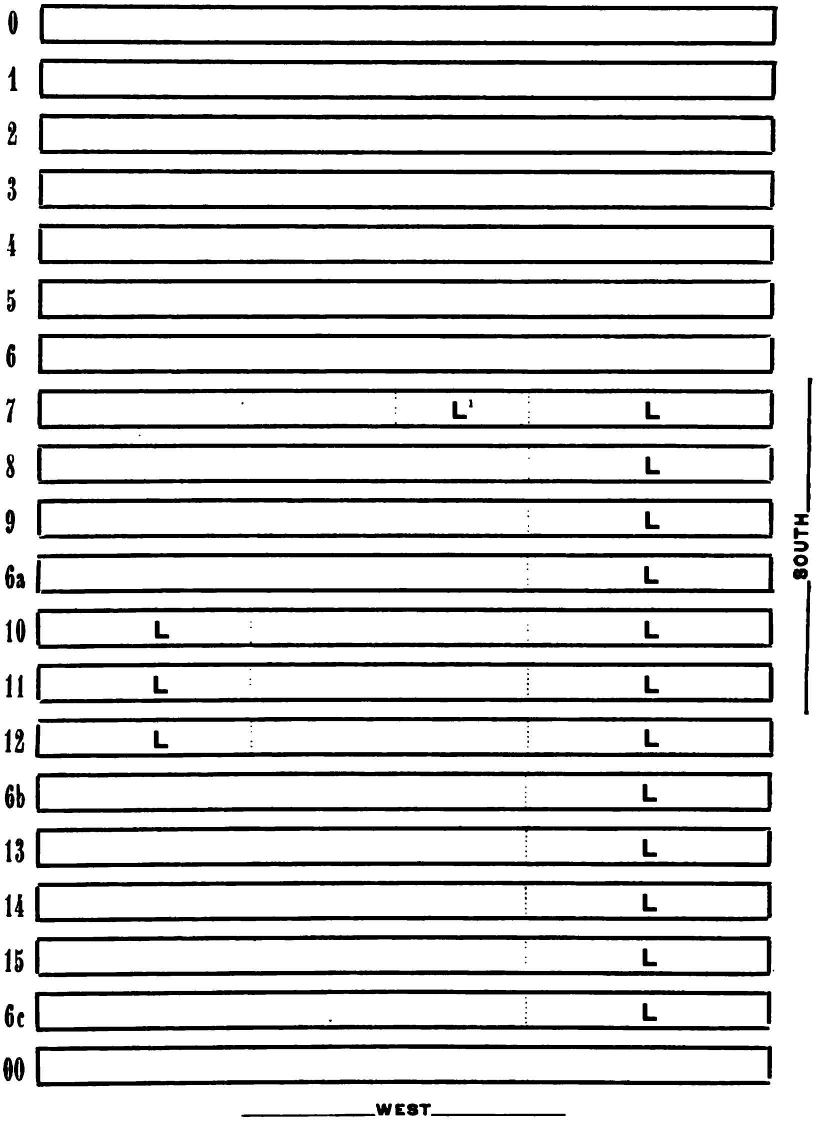
* R. I. Expt. Sta. Rep. for 1893, p. 201.

DIAGRAM OF THE ONE-TWENTIETH ACRE PLOTS.



The figures at the left of the above diagram indicate the plot numbers.

The plots are 208 feet long and 10.47 feet wide.

The width of the paths between the plots is 3 feet.

The section on the south end of plots 7 to 6c, inclusive, and also the section on the north end of plots 10, 11 and 12, all of which are designated by the letter "L," received air-slacked lime in 1893 at the rate of 2½ tons per acre. In 1894 the section on plot 7 designated by L[1] received air-slacked lime at the rate of 3 tons per acre, and enough was added to the other section (L) to make the total amount on the south half of the plot equal to 3 tons per acre.

The rate and kinds of other fertilizers are shown in the following table:

TABLE SHOWING FERTILIZERS APPLIED TO THE ONE-TWENTIETH ACRE PLOTS.

Plot Number.	RATES PER ACRE.					RATES PER PLOT.				
	Nitrate of Soda.	Dissolved Bone-black.	Muriate of Potash.	Sulphate of Ammonia.	Dried Blood.	Nitrate of Soda.	Dissolved Bone-black.	Muriate of Potash.	Sulphate of Ammonia.	Dried Blood.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs
0	....	....	....	....	....	....	....	....	....	....
1	150	....	....	....	....	7.5	....	....	....	....
2	....	350	....	....	....	....	17.5	....	....	....
3	....	....	130	....	....	....	...	6.5	....	....
4	150	350	....	....	....	7.5	17.5	...	....	....
5	150	....	130	....	....	7.5	....	6.5	....	...
6	....	350	130	....	....	....	17.5	6.5	....	....
7	150	350	130	....	....	7.5	17.5	6.5	...	....
8	300	350	130	....	....	15.0	17.5	6 5	....	....
9	450	350	130	....	..	22.5	17.5	6 5	....	....
6a	....	350	130	....	....	....	17.5	6.5	....	....
10	....	350	130	116	....	....	17.5	6.5	5.8	....
11	....	350	130	232	....	....	17.5	6.5	11.6	....
12	....	350	130	348	....	....	17.6	6.5	17.4	...
6b	....	350	130	....	....	....	17.5	6.5	....	....
13	....	350	130	....	220	....	17.5	6.5	....	11.0
14	....	350	130	....	440	....	17.5	6.5	....	22.0
15	....	350	130	....	660	....	17.5	6 5	....	33.0
6c	....	350	130	....	....	....	17.5	6 5	....	...
00	....	....	....	....	....	....	....	....	....	....

TABLE SHOWING WEIGHTS IN TONS AND FRACTIONS OF TONS OF OATS WEIGHED GREEN.

Plot Numbers.	Limed Section, North End.	Unlimed Section.	Limed Section, South End.	Gain on South Limed Section.	Per cent. of gain by use of Lime.
8*	......	7.073	8.194	1.121	15.85
9	......	6.761	7.722	0.961	14.21
6a	......	1.664	3.782	2.118	127.28
10	6.880	3.306	6.776	3.470	104.96
11	10 874	2.600	8.667	6.067	233.35
12	10.165	2.246	9.297	7.051	318.39
6b	......	2.704	5.043	2.339	86.50
13	......	3.536,	5.358	1.822	51.52
14	......	4 784	7.249	2.465	51.52
15	......	5.206	8.982	3 776	72.53
6c	......	2.288	5.043	2.755	120.41
00	......	.....	.....	.....	......

* For crops on plots 0 to 7, see Article on Soil Tests in this report.

From the above table it is evident that the application of air-slacked lime to the sulphate of ammonia plots (10, 11 and 12) gave greater yields than upon either the nitrate of soda or the dried blood, although the gain in all cases was much more than to cover the extra expense of liming. The result obtained is strong evidence that oats require an alkaline soil for their most productive growth, and that the sulphate of ammonia, especially, is used to disadvantage on an acid soil. Other experiments have pointed toward the same conclusion.

EXPERIMENT WITH LEGUMINOUS PLANTS.

The experiment with leguminous plants which began last year* upon plots 17, 19 and 21, was continued through this year with slightly varying results. The three plots received like quantities of potash and phosphoric acid, but plot 17 received no nitrogen, plot 19 received one-third ration, and plot 21 full ration. In nearly every case in 1893 the plot (19) that received one-third ration (150 lbs.) of nitrate of soda gave a larger yield than either plot 17 or 21. While in 1894 a majority of the plants on the full-ration plot (21) gave the largest yields, although the gain was not great except in two or three cases; in no case was the gain in weight of plot 21 over plot 19 sufficient to cover the expense of applying the extra 300 lbs. of nitrate of soda.

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* R I. Agl. Expt Sta. Rep. 1893, p. 190.

PLOT NO.	17	19	21	Average height of the mature plant given in inches.	Usual method of sowing the crop.	Date of harvesting the crop.*	Excess of yield with one-third ration of nitrogen over no nitrogen.	Excess of yield with full ration of nitrogen over no nitrogen.
Phosphate Rock.....lbs. per acre..	1200	1200	1200					
Muriate of Potash... " " ..	180	180	180					
Nitrate of Soda...... " " ..	....	150	450					
NAMES OF CROPS.‡	Weight given in pounds.	Weight given in pounds.	Weight given in pounds.					
						1894.		
Red Clover	5.0	8.2	7.8	18	B.†	Aug. 22	3.2	2.8
Mammoth Clover	6.2	13.4	11.1	20	B.	Aug. 22	7.2	4.9
Bokhara Clover	6.1	23.2	21.9	70	B	Aug. 22	17.1	15.8
Yellow Lupine	39.4	41.9	65.5	35	B.	Sept. 28	2.5	26.1
English Horse Bean	3.0	6.5	18.8	28	B.	Sept. 28	3.5	15.8
Soja Bean, Common	63.1	73.4	75.4	36	D. 24	Sept. 28	10.3	12.3
Soja Bean, Medium Green	10.0	12.3	14.7	36	D. 24	Oct. 20	2.3	4.7
Soja Bean, Medium Green ..(beans)	3.8	5.0	5.9	....	....	....	1.2	2.1
Soja Bean, Medium Black	7.0	8.1	10.3	36	D 24	Oct. 30	1.1	3.3
Soja Bean, Medium Black...(beans)	3.1	4.1	4.4	....	....	....	1.0	1.3
Soja Bean, Early White	9.9	10.8	11.1	36	D. 24	Oct. 15	0.9	1.2
Soja Bean, Early White.....(beans)	5.5	5.8	3.8	...	....	....	0.3	0.0
Black Podded Adzuki	7.3	7.6	11.5	30	D 24	Oct. 20	0.3	4.2
Black Podded Adzuki.......(beans)	2.1	2.0	2.7	....	....	....	0.0	0.6
White Podded Adzuki	10.3	10.5	13.0	30	D. 24	Oct. 15	0.2	2.7
White Podded Adzuki.......(beans)	6.1	6.1	7.3	....	....	....	0.0	1.2
Kiyusuke Daidzu	11.6	13.4	12.9	38	D. 24	Oct. 19	1.8	1.3
Kiyusuke Daidzu...........(beans)	3.8	4.4	4.7	....	....	....	0.6	0.9
Yamagata Daidzu	54.1	55.7	67.5	36	D. 24	Sept. 28	1.6	13.4
Eda-mame	9.4	10.3	11.7	36	D. 24	Oct. 19	0.9	2.3
Eda-mame...............(beans)	3.8	4.2	4.9	...	....	....	0.4	1.1
Yellow Soy	13.8	16.6	18.8	36	D. 24	Oct. 15	2.8	5.8
Yellow Soy..............(beans)	6.6	5.0	7.6	...	....	....	0.0	1.0
Golden Wax Bean	10.1	9.6	6.8	18	D. 24	Aug. 14	0.0	0.0
Peas	5.3	8.5	5.7	14	B.	Aug 31	3.2	0.4
Peas in pod	3.4	4.6	3.8	....	....	......	1.2	0.4
Cowpea	113.3	113.3	134.8	28	B or D. 24	Sept. 28	0.0	21.5
Spurry	16.6	21.0	20.6	14	B.	Aug. 22	4.4	4.0

* All of the seeds were planted on June 13, 1894.

† B. — broadcast; D. — drilled. The figures show distance in inches between drills.

‡ The figures represent the weights of the whole plant above ground unless otherwise stated.

It will be noticed in the preceding table that about one-half of the plants gave a greater yield on plot 19 than on plot 17, sufficient to warrant the application of the nitrate of soda, which cost about $5 per acre, while in the remainder it was doubtful if the application was a paying investment.

The clovers seemed to be most benefited by the application of the one-third ration of nitrogen, and lost in weight when the larger quantity was applied.

With most of the soja beans the increase of yield is not sufficient to cover the cost of applying any nitrogen at all the second year, while in the first year there was a slight profit made by applying the one-third ration.

Since the application of the one-third ration to plot 19 has brought, the second year, on the average, the yields of that plot down to nearly the same quantity as those of plots 17 and 21, it appears that a small amount of nitrogen such as was applied to plot 19 in 1893 was more beneficial than a large amount, and also gave a better yield than where no nitrogen whatever was used.

For the purpose of showing the feeding values of some of the most common leguminous plants used in America as green fodders, and to compare their value with other standard green fodders, the following table was compiled. The figures were taken in part from U. S. Department of Agriculture "Compilations of Analyses of American Feeding Stuffs" and in part from the Massachusetts Agricultural Experiment Station Reports. From the analyses made of most of the plants it is evident that their value as cattle food or as green manure has not become widely known among the farmers.

TABLE SHOWING ANALYSES OF SOME LEGUMINOUS PLANTS AS COMPARED WITH CORN, OATS, AND MILLET.

GREEN FODDERS. Name of Crop.	Number of analyses made.	Per cent. of Water.	Percentage Composition of Dry Matter.				
			Ash.	Protein.	Fibre.	Nitrogen—free extract.	Fat.
Red Clover	43	70.79	7.20	15.30	27.80	45.80	3.9
Bokhara Clover	6	75.23	7.50	13.20	30.30	45.20	3.7
Alfalfa	23	71.75	9.40	17.10	26.20	43.90	3.4
White Lupine	1	85.35	5.03	18.71	31.18	42.67	2.4
Yellow Lupine	1	86.05	11.14	17.84	27.10	42.05	1.9
Horse Bean	1	84.83	5.80	16.68	28.17	47.09	2.3
Soja Bean	21	75.19	9.74	14.63	27.74	43.72	4.2
Soja Bean (early white)	1	66.56	15.25	17.63	27.12	37.23	2.8
Soja Bean (early green)	1	69.84	12.97	19.35	23.51	40.30	3.9
Soja Bean (medium black)	1	76.87	12.66	21.67	21.73	37.18	6.8
Soja Bean (late)	1	79.78	21.33	18.56	23.62	34.24	2.3
Cowpea	10	83.55	10.50	14.30	29.00	43.60	2.6
Vetch	5	83.84	11.20	28.20	16.80	39.90	4.0
Spurry	..	.....	.....	....	.....	.....	..
Serradella	6	79.43	17.10	13.60	26.20	39.90	3.1
Sainfoin	2	75.16	12.30	16.80	22.10	45.50	3.3
Flatpea (*Lathyrus silvestris*)	1	78.62	8.91	30.65	20.38	35.06	5.0
Fodder Corn	31	79.71	5.90	9.86	25.29	56.51	2.4
Green Oats	6	74.03	5.70	7.51	31.84	52.79	2.2
Common Millet	9	64.58	4.84	7.50	30.99	53.93	2.7

The *red clover* used in the experiment is our common red clover which, when sown with grass seed, requires 8 or 10 lbs. per acre, but when sown alone or with grain, 15 or 20 lbs. is not too much. Sow in July or early August, or on a light snow in March.

Mammoth clover is similar to the red, being a giant variety of that clover. It requires a little less seed per acre and should be sown as stated above for red clover.

Bokhara clover is a Russian legume which grows nearly six feet high, with a hard, woody stem, and branches considerably. It is too coarse to make good fodder, but is a good nitrogen-catcher if turned under before it gets too high. It blossoms profusely and furnishes excellent bee pasture. From 12 to 15 lbs. of seed are required per acre.

Lupine does not make a suitable fodder, but is excellent for green manuring. It is a thoroughly European plant and is much valued there. The varieties do not vary much in value, and all thrive better on rather poor soil than many other legumes. The seed is as large as a small pea and ripens here.

The *English Horse Bean* is highly prized as a fodder plant and for its seed in the country from which it takes its name. It is very good for the silo when cut before the beans get hard. About two-thirds of a bushel of seed is sown per acre. The plant has an insect enemy (Bean Leaf-hopper) which makes it rather difficult to raise successfully. Kerosene emulsion is used when the insects are in the larval state with satisfactory results.

All varieties of *Soja Beans* are used profitably either as silage, as green fodder, or as a green manure. They grow readily; the *Common* variety and the *Early White* are among the earliest to mature. One bushel of seed is required per acre.

Black Podded Adzuki, *White Podded Adzuki*, *Kiyusuke Daidzu*, *Yamagata Daidzu*, *Eda-mame* and *Yellow Soy*, are Asiatic varieties of beans similar to the soja beans. The seed of these varieties, as well as the soja beans, makes an excellent, rich meal for stock feeding, while the Black Podded Adzuki beans are said to be desirable and nutritious for table use.

Cowpea makes excellent ensilage, and is also used a great deal for green manuring. The bush varieties require about five pecks of seed per acre, while the most improved running varieties require only four to six quarts, but the latter seed is far more expensive. The seed does not mature in this climate, but is raised extensively in southern United States.

Spurry makes a very good forage plant for cattle and sheep. It is fine in growth, matures very quickly and has a little round black seed which shells easily, and soon the ground will be well covered with self-sown seed. Fifteen or eighteen pounds of seed are used per acre. Care should be exercised about sowing it in rich fields where it might become a nuisance as a weed. We believe it well worthy of trial on pastures where the soil is open and thin.

RESULTS OF THE TRIALS OF ALFALFA. (*Medicago sativa*).

This plant is a perennial legume, known in France as Lucerne, but in this country it commonly takes the Italian name of Alfalfa. It is a very valuable plant in warm countries, but our severe winters usually destroy it the first season of its growth. A good field of it has not been successfully grown in this State, so far as we have been able to ascertain, although single plants occasionally survive the first winter, after which there seems to be no trouble.

One of the permanent plots on the "plain," number 16, was sown to alfalfa on May 25th, 1893, at the rate of 20 lbs. per acre. The ground had been ploughed, and the following weights of fertilizers were applied per acre and harrowed in: dissolved bone, 240 lbs.; tankage, 300 lbs.; muriate of potash, 120 lbs.; and slag meal, 300 lbs.

The seed, which was sown in drills seven inches apart, germinated well, and the young plants grew nicely, though slowly, as is natural to them when young. The plot was kept free from weeds by hand, requiring about the same attention as carrots. In September it reached a height of four to eight inches and bloomed, at which time it was clipped with a scythe and the tops allowed to remain on the ground for a mulch; and in the early winter a mulch of seaweed at the rate of eight cords per acre was spread over it to serve as a protection against frost. But a very few plants survived the winter, and they soon died out altogether.

The soil of our "plain" is mechanically well adapted to growing alfalfa, for it is of a light, sandy character, and has gravelly subsoil through which the roots can easily penetrate to the water table below. From our recent experience with a number of varieties of legumes, and especially clover, a great benefit was received by the application of lime.* Good stands of clover have been secured through its use when none would grow without it. We conclude, therefore, that the soil perhaps lacked that quality which can be supplied by a liberal application of air-slacked lime; for this reason, perhaps, the plants lacked a certain vigor and hardiness or were not developed sufficiently to withstand the action of the frost. We propose to apply three tons per acre of air-slacked lime to this plot and repeat the trial of alfalfa upon it. Perhaps the reason for the common failure in getting the alfalfa to germinate is in the faulty preparation of the soil before the seed is sown. Very few crops respond more readily to a well cultivated, mellow soil than does alfalfa. It may be sown either in drills or broadcast. The latter method will require a slightly larger quantity of seed per acre than the former. If the soil is dry, rolling after sowing will assist germination.

To make the best fodder for cattle it should be cut, whatever height it may have attained, just before blossoming, for if it is allowed to blossom the stalks get too hard and indigestible. It requires good weather to cure it and it should be well made before storing in the barn.

After the first year, when it is well established, several crops may be cut every season for ten, twelve or more years. The fodder contains a large amount of protein, and if fed green should be mixed with hay or straw as there is more or less danger of causing the cattle to bloat if fed alone.

Another piece of ground was sown to alfalfa July 12, 1894. The south half of plot 47 was chosen and fertilized as follows: Dissolved phosphate rock, 420 lbs.; slag meal, 480 lbs.; nitrate of soda, 300 lbs.; and muriate of potash, 120 lbs. per acre; and the seed was put in drills seven inches apart on the west half of the piece at the rate of 20 lbs. per acre and sown broadcast on the east half. This plot is located in a more moist position than the one on which the alfalfa was sown the previous year. It all grew finely and there was no apparent difference between the drilled half and that sown broadcast. When about eight inches high, just before blossoming in the fall, it was cut so as to leave about half of the plant standing and the remainder left on the ground as a mulch. The chief object of the cropping was to induce as great a root growth as possible before the cold weather set in. It was in better condition to go through its first winter than that sown the previous year, and may withstand the severe weather. Further results will be noted hereafter.

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* R. I. Agl. Expt. Sta. Rep. for 1893, p. 193.

TESTING THE VALUE OF PHOSPHORIC ACID IN DIFFERENT FORMS.

In 1892 experiments were conducted on the hill with Indian corn, and on the plain with Indian corn and cowpeas, to test the value of phosphoric acid in five different forms commonly used in the manufacture of fertilizers. In these trials Dissolved South Carolina Rock, Floats, Dissolved Boneblack, Slag Meal, and Double Superphosphate were used. The records of this work are found on pages 141 and 142 of the Fifth Annual Report.

While the results of these trials were inconclusive, they yet proved the importance of the experiment and promised an interesting field for further investigation. Owing to the facts that it became necessary to cut a road across the plots on the hill, and that there were several other phosphates to test in this connection, a new area was selected for this work. Two plots were assigned for each form of phosphate, one of which was to receive air-slacked lime in addition to the phosphoric acid, and every plot to receive a liberal and equal dressing of potash and nitrogen. An *equal money value of phosphoric acid* was applied in each case, using Boneblack as a standard.

The land thus selected was of uniform character and had not been treated with fertilizer for a number of years, producing only a light crop of hay prior to the year previous to the beginning of our experiment, when with no application of fertilizer it was planted to Indian corn, the result of which, showing a marked degree of exhaustion, is given in the following table:

TABLE SHOWING YIELDS OF INDIAN CORN IN 1893, PREVIOUS TO THE PHOSPHATE EXPERIMENT.

The plots had no fertilizer applied to them for the four years preceding 1894.

Plot Numbers.	Total weight of corn and stover.	Weight of stover.	Weight of corn.	Weight of large ears of corn.	Weight of inferior ears of corn.	Ratio of stover to total corn.
51	290	131.0	159.0	128.0	31.0	1 : 1.21
52	240	108.0	132.0	103.5	28.5	1 : 1.22
53	230	108.0	124.0	101.0	23.0	1 : 1.15
54	200	97.0	103.0	65.0	38.0	1 : 1.06
55	275	135.2	139.8	112.8	27.0	1 : 1.03
56	185	90.0	95.0	83.0	12.0	1 : 1.05
57	275	132.5	142.5	117.5	25.0	1 : 1.08
58	165	92.0	73.0	35.0	38.0	1 : 0.79
59	265	138.0	127.0	107.0	20.0	1 : 0.92
60	150	64.0	86.0	65.0	21.0	1 : 1.34
61	175	95.5	79.5	59.5	20.0	1 : 0.83
62	165	74.5	90.5	71.5	19.0	1 : 1.21
63	215	103.5	111.5	94.0	17.5	1 : 1.08
64	170	71.5	98.5	82.0	16.5	1 : 1.38
65	210	96.2	113.8	86.5	27.3	1 : 1.18
66	220	73.5	146.5	128.5	18.0	1 : 1.99
67	235	105.2	129.8	107.5	22.8	1 : 1.23
68	210	86.7	123.3	97.5	25.8	1 : 1.42

NOTE.—The weights are given in pounds.

The experiment as now planned is to be conducted a number of years, using phosphoric acid in the same form each succeeding year, as shown in the following table. The crop will be changed each year to conform to some suitable rotation, using the same crop for all the plots.

The following table gives the results of the first crop after the application of fertilizer. As the effect of the application of phosphoric acid in slowly soluble forms is not apparent for some time, several years must necessarily elapse before definite conclusions can be reached.

TABLE SHOWING THE RESULTS OF VARIOUS KINDS OF PHOSPHATES USED, IN QUANTITIES HAVING AN EQUAL MONEY VALUE, BOTH WITH AND WITHOUT LIME, UPON INDIAN CORN IN 1894.

MATERIALS USED TO SUPPLY PHOSPHORIC ACID.	Weight in lbs. of fertilizing materials per acre.†	Plot* Numbers.	Total weight of corn and stover.	Weight of stover.	Weight of corn.	Weight of large ears of corn.	Weight of inferior ears of corn.	Gain or loss of stover over plot 68.	Gain (+) or loss (—) in total weight of corn over plot 68.	Ratio of stover to total corn.
Dissolved Boneblack........	600	51—limed...	822	371.0	451.0	404.5	46.5	+220.3	+261.7	1: 1.32
		52—unlimed.	508	138.2	369.8	311.8	58.0	— 12.5	+180.5	1: 2.68
Dissolved Bone.............	504	53—limed...	630	272.0	358.0	301.5	56.5	+121.3	+168.7	1: 1.32
		54—unlimed.	452	183.2	268.8	220.3	48.5	+ 32.5	+ 79.5	1: 1.47
Dissolved Phosphate Rock..	927	55—limed...	710	314.7	395.3	350.8	44.5	+164.0	+206.0	1: 1.26
		56—unlimed.	580	254.5	325.5	287.5	38.0	+103.8	+136.2	1: 1.28
Fine Ground Bone..........	423	57—limed...	458	192.5	265.5	212.5	53.0	+ 41.8	+ 76.2	1: 1.38
		58—unlimed.	412	186.5	225.5	175.5	50.0	+ 35.8	+ 36.0	1: 1.21
Slag Meal..................	766	59—limed...	565	242.0	323.0	272.0	51.0	+ 91.3	+133.5	1: 1.33
		60—unlimed.	435	197.3	237.7	200.3	37.4	+ 46.6	+ 48.4	1: 1.20
Floats‡....................	927	61—limed...	390	221.0	169.0	85.0	74.0	+ 70.3	— 20.3	1: 0.76
		62—unlimed.	339	144.2	194.8	111.0	83.8	— 6.5	+ 5.5	1: 1.35
Alumina Phosphate (raw)...	528	63—limed...	345	201.2	143.8	111.8	32.0	+ 50.5	— 45.5	1: 0.71
		64—unlimed.	300	153.7	146.3	100.0	46.3	+ 3.0	— 43.0	1: 0.95
Alumina Phosphate (ignited)	330	65—limed...	430	192.7	237.3	186.0	51.3	+ 42.0	+ 47.7	1: 1.23
		66—unlimed.	260	128.2	131.8	81.0	50.8	— 22.5	— 57.5	1: 1.03
No Phosphoric Acid...........		67—limed...	460	198.7	261.3	192.0	69.3	+ 48.0	+ 72.0	1: 1.24
		68—unlimed.	340	150.7	189.3	167.8	21.5	.....	.....	1: 1.25

NOTE.—All weights are given in pounds.

* Each plot contains two-fifteenths of an acre.

† Each plot received an application of nitrate of soda at the rate of 150 lbs. per acre and muriate of potash at the rate of 240 lbs. Where lime was used it was applied at the rate of one ton per acre.

‡ Undissolved phosphate rock ground very fine.

MATERIALS USED TO SUPPLY PHOSPHORIC ACID.	Cost per ton delivered at Kingston.	ANALYSIS.					Weight per "struck" bushel—pounds.	REMARKS.
		PHOSPHORIC ACID.						
		Per cent. Soluble.	Per cent. Reverted.	Per cent. Insoluble.	Total percentage.	Per cent. Nitrogen.		
Dissolved Boneblack............	$23 20	16 00	.29	.19	16.48	....	61	Black or slate color: odorless.
Fine Ground Bone..............	30 20	.....	.....	.....	26.75	1 95	68	Dusty: disagreeable to handle.
Dissolved Bone.................	25 20	11.62	3.92	.49	16.03	1.41	65	Acid liable to destroy the bags.
Floats.........................	14 20	trace.	2 34	21.53	23.87	....	88	Odorless: somewhat dusty.
Dissolved Phosphate Rock......	14 20	12.24	2 16	1.05	15.45	....	79	Odor not disagreeable.
Slag Meal......................	21 20	....	8 20	10 96	19.16	....	109	Odorless.
Raw Alumina Phosphate........	.....	.....	.....	.....	35.00	....	90	Odorless: pink in color.
Ignited Alumina Phosphate.....	....	.13	32.26	13.41	45.80	....	72	Odorless: color, dark slate.

DESCRIPTION OF PHOSPHATIC MATERIALS USED.

Dissolved Boneblack is prepared by heating raw bones in a closed cylinder to drive off the gas, water and oily matters, the process resulting in the formation of bone charcoal. This bone charcoal after being used in clarifying sugar is known as "spent boneblack." When the spent boneblack comes to us as fertilizer it is practically free from nitrogen. The raw spent boneblack is treated with sulphuric acid, and nearly all the phosphoric acid is thereby rendered soluble. This material is pleasant to handle and generally has no offensive odor.

Fine Ground Bone is manufactured chiefly from bones obtained at the meat markets and slaughter-houses. The raw bones are subjected to a process by which the fat and other organic elements are largely removed, leaving the bones thoroughly dry, in which condition they are ground to a fine powder. This material is so very fine that when applied alone, or in the operation of mixing, it fills the air with a dust very unpleasant for men and animals who are obliged to breathe it. If kept through the winter it is liable to gather moisture and become lumpy and difficult to pulverize.

Dissolved Bone is fine ground bone treated with sulphuric acid. This treatment adds considerable weight to the material in the form of acid and water applied and reduces the percentage of phosphoric acid and nitrogen, while rendering the former more available to the plant.

Floats is finely ground phosphate rock such as is obtained from the phosphate mines of Florida, South Carolina, Tennessee, and elsewhere. These phosphate mines are the natural deposit of the fossil remains of gigantic reptiles, sea monsters, animals and shell fish of the age in the earth's history immediately preceding the "age of man." While the phosphate rock is of animal origin, it differs from bone in this respect that it contains no nitrogen or organic matter, and therefore is not so readily decomposed in the soil even when applied in a finely-ground condition. When rendered soluble by treatment with sulphuric acid, however, the phosphoric acid is *just as valuable* as when derived from bone or any other source.

Dissolved South Carolina Rock, *Dissolved Phosphate Rock*, or *Acid Phosphate*, is the Floats or ground rock rendered soluble by treatment with sulphuric acid. This and the preceding phosphates bear to each other a relation similar to that of "fine ground" and "dissolved bone." Dissolved Phosphate Rock is more agreeable to handle than Floats, as it is lighter and free from dust.

Slag Meal or *Thomas Slag* is named from the inventor of a process by which phosphorus is removed from iron in the process of making steel. There are many iron ores which contain a small quantity of phosphorus, and the ordinary process of smelting failed to remove this material. If the phosphorus is not removed steel made from such iron is brittle. The Thomas process consists of putting a quantity of iron ore and about twenty per cent. of lime into a converter and submitting the whole to an intense heat. The silica, phosphorus, some iron oxides and various impurities, unite with the lime to form a slag which floats on the melted steel. This material when cold is finely ground and forms the "slag meal" or "Thomas Slag" of commerce. The composition of the product of different works is variable, and its solubility is influenced by the presence of a greater or less amount of certain impurities. The occasional remarkable benefit derived from its use compared with that obtained from other phosphatic materials is doubtless due to a large extent to the presence in it of considerable lime. In proportion to bulk it is heavier than any of the other forms of phosphate used.

Raw Alumina Phosphate is a finely-ground rock phosphate found in certain sections of Florida and certain islands in the Gulf of Mexico and elsewhere. It is so called because the phosphoric acid is combined chiefly with alumina and iron instead of with lime as in most other phosphates. This material is said to have been used by fertilizer manufacturers as a "filler" to raise the per cent. of *total* phosphoric acid, although in this condition it can be of little value to the farmer.

Ignited Alumina Phosphate is the material previously described which has ostensibly been roasted or heated. By the process most of the phosphoric acid is rendered soluble in a citrate of ammonia solution, in which condition it is classed as "reverted" or "available" phosphoric acid. The results secured from its use the past season would indicate that it is nevertheless inferior in its action to "available" phosphoric acid from most other materials.

CHEMICAL DIVISION.

H. J. WHEELER.

The duties of the chemical division for the year 1894 have been along several lines, each of which will be described separately.

FERTILIZER INSPECTION.

The first work of the fertilizer inspection in each year involves the collection of samples of such brands of fertilizing material, including wood-ashes, agricultural chemicals, etc., as are offered for sale in the State. This duty, as well as the analysis of the samples, devolves, according to the provisions of our law, upon the chemical division of the Station. The time of one man for about a month is consumed in travelling about the State collecting samples. The total number of samples collected and analyzed in 1894 was one hundred and eight, divided as follows: Samples of complete commercial fertilizers, eighty-one; bone, nine; unleached wood-ashes, six; nitrate of soda, three; tankage, two; fish, two; dissolved boneblack, one; dissolved bone, one; muriate of potash, one; sulphate of potash, one; kainite, one. The results of these analyses have been published in the Station Bulletins and have also been embodied in a detailed account of the fertilizer inspection for the year, which comprises an annual report to the State Board of Agriculture.

INVESTIGATION OF METHODS OF POTASH DETERMINATION.

The Chemist of the Station was appointed, in August, 1893, as Reporter on Potash for 1893 and 1894 by the Association of Official Agricultural Chemists. The investigation outlined and conducted was essentially a comparison of the Lindo-Gladding and alternate methods of potash determination. This work occupied considerable time, yet work of this nature is of the utmost importance in connection with the administration of the fertilizer inspection. The results obtained in this investigation may be found in the "Proceedings"* of the above mentioned association for 1894.

MISCELLANEOUS ANALYSES.

Aside from the analyses in connection with the official inspection of fertilizing materials, examinations of many miscellaneous materials have been made; these involved a large number of acid tests of soils from Rhode Island and other parts of New England, and determinations of moisture in plants in connection with field and pot experiments. Eleven analyses of private interest only have been made at the request of various parties, for which the Station has received pay at commercial rates.

Nos. 171 to 176 inclusive were analyses of materials used at the Station in connection with the experimental work in 1893; the analyses of materials used in 1894, as well as other unpublished miscellaneous analyses, may be found in the following pages.

Phosphatic Fertilizers.

Used at the Station.

177. Dissolved Boneblack.
178. Dissolved South Carolina Rock.
179. Slag Meal.

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* Bulletin No 43. U. S. Dept. of Agriculture, Division of Chemistry, Washington, 1894.

	177	178	179
	Per cent.	Per cent.	Per cent.
Water	14.75	17.87	1.14
Soluble phosphoric acid	16.00	12.24	0 00
Reverted phosphoric acid	.29	2 16	8.20
Available phosphoric acid	16.29	14.40	8 20
Insoluble phosphoric acid	.19	1 05	10.96
Total phosphoric acid	16.48	15.45	19.16

No. 179, Slag Meal or Thomas Slag, also known under several other names, is a by-product obtained in the manufacture of steel from iron phosphate. The value of this material depends very decidedly upon the composition of the materials employed and upon the process of manufacture. The results with this material have proved in some instances nearly equal to those with superphosphate, while in other cases they have been far from satisfactory. Doubtless in many instances the beneficial results may be attributed largely to the high percentage of lime which it contains. Hoyermann, a phosphate manufacturer in Hanover, Germany, and also Prof. Mærcker of Halle, have claimed recently to have ascertained what conditions of manufacture affect materially the availability of this phosphate, and it is possible that in the future material of more constant value may be produced.

Phosphatic Fertilizers.

Used at the Station.

180. Ground Alumina Phosphate (Raw).
181. Ground Alumina Phosphate (Ignited).
182. Floats (Pulverized Undissolved Phosphate Rock).

	180	181	182
	Per cent.	Per cent.	Per cent.
Water	4.66	.70	1.39
Soluble phosphoric acid	0.00	.13	trace.
Reverted phosphoric acid	.00	32.26	2.34
Available phosphoric acid	.00	32.39	2.34
Insoluble phosphoric acid	35.00	13.41	21.53
Total phosphoric acid	35.00	45.80	23.78

The alumina phosphates have been introduced recently into commercial fertilizers to a considerable extent. It will be seen that the ignited phosphate contains a high percentage of what is shown by chemical analysis to be reverted phosphoric acid, yet notwithstanding this the results secured with it during 1894 have been highly unsatisfactory, and it appears doubtful if so-called available phosphoric acid in the form of alumina phosphate approaches in value that in the form of the better known phosphates.

In regard to Floats, certain parties claim that their application is profitable, especially upon low, wet lands, yet the consensus of opinion still appears to be that they cannot be considered so economical as superphosphates. In all cases where prompt action from the use of phosphoric acid is desired this material must be left wholly out of consideration.

Sodium Salts.

Used at the Station.

183. Sodium chloride (common salt).
184. Sodium carbonate (soda ash).

	183 Per cent.	*184* Per cent.
Sodium oxide (soda)	51.04	57.00

Potassium Nitrate.

Used at the Station	*185* Per cent.
Water	1.80
Nitrogen	12.48
Potash	44 36
Chlorine	1.74

This is an excellent material for fertilizing purposes, since it contains both potash and nitrogen in available form. The only drawback to its use at present is its cost, and since the constituents which it furnishes may be bought more cheaply in the form of muriate of potash and nitrate of soda, the latter are generally employed in its stead.

Double Sulphate of Potash and Magnesia.

Used at the Station.	*186* Per cent.
Water	11.91
Potash	21.37
Magnesium oxide	13.68
Sulphuric acid (SO_3)	44.97

This material should have contained about 27 per cent. of potash. It has been sold recently as sulphate of potash and as *high grade* sulphate of potash; in fact, however, the latter contains about 48 per cent. of potash, and the farmers of the State should, in the purchase of sulphate of potash, make sure that the one substance is not palmed off upon them for the other.

Muriate of Potash.

187. Used at the Station.
188. Sent by T. H. Barber, Arcadia, R. I.

	187 Per cent.	*188* Per cent.
Water	.11	.....
Potash	54.10	49.64

Potassium Carbonate.

Used at the Station.	*189* Per cent.	*190* Per cent.
Potash	56 39	50.71
Soda	.....	14.09

Dried Blood.

191. Sent by J. A. Budlong & Son, Auburn, R. I.
192 and 193. Used at the Station.

	191 Per cent.	*192* Per cent.	*193* Per cent.
Water	29.36	8.14	16 76
Nitrogen	7.16	9.19	9.87
Phosphoric acid	.....	1.68	.....

Many lots of "dried" blood are sold which still contain large quantities of water; in all such cases the percentage of nitrogen is decidedly reduced, and many times to such an extent that the material is not worth over two-thirds what it would be if properly dried. In some instances also leather and other materials are doubtless mixed with the blood as an adulterant, and for this reason a guaranty of its purity should be obtained.

Sulphate of Ammonia.

Used at the Station.

	194 Per cent.
Water	2.54
Nitrogen	19.58

Wool Waste.

195. Sent by Benj. F. Smith, Pawtucket, R. I.

196 and 197. Sent by the American DeGras and Chemical Co., Providence, R. I.

	195 Per cent.	196 Per cent.	197 Per cent.
Water	2.31	16.14	14.89
Nitrogen	2.00	1.65	.06
Phosphoric acid	.15	.08	.06
Potash	.25	.47	.39
Insoluble matter	.....	46.82	74.82

Nos. 195 and 196 were probably "press cake," and No. 197 is a product obtained during the manufacture of "de gras" from wool waste and commonly called "tankage." It will be seen that the latter is of but trifling value as a fertilizer, and it should not be mistaken for the tankage from rendering establishments which contains 6 to 8 per cent. of nitrogen and 10 to 12 per cent. of phosphoric acid.

Peruvian Guano.

Sent by J. A. Budlong & Son, Auburn, R. I.

	198 Per cent.
Water	10.18
Nitrogen in nitrates	2.70
Nitrogen in ammonia salts	5.23
Nitrogen in organic matter	.40
Total nitrogen	8 33
Soluble phosphoric acid	2.00
Reverted phosphoric acid	5 42
Available phosphoric acid	7.42
Insoluble phosphoric acid	4.00
Total phosphoric acid	11.42
Potash	1.94
Chlorine	1.56

At the present time practically none of the original Peruvian guano containing a large percentage of nitrogen can be obtained, as the supply is practically exhausted. The guano as now obtained contains much less nitrogen than formerly, and before it is put upon the market generally receives additions of nitrate of soda and sulphate of ammonia in order to make the percentage of nitrogen practically like that of the original Peruvian guano. In all probability a cheaper and perhaps equally effective article might be obtained by the use of dissolved phosphate rock, nitrate of soda and muriate of potash.

Fertilizer.

Sent by J. A. Peckham, Middletown, R. I.

	199 Per cent.
Water	20 03
Nitrogen in nitrates	3.02
Nitrogen in ammonia salts	.....
Nitrogen in organic matter	2.01
Total nitrogen	5.03

	Per cent.
Soluble phosphoric acid	1.45
Reverted phosphoric acid	2.29
Available phosphoric acid	3.74
Insoluble phosphoric acid	4.59
Total phosphoric acid	8.33
Potash	4.40
Chlorine	.87

Wood Ashes.

Sent by B. C. Sherman, Portsmouth, R. I.

	200 Per cent.
Water	20.12
Phosphoric acid	1.78
Potash	5.05

Muck.

Sent by Oliver W. Nichols, Wakefield, R. I.

	201 Per cent.
Water	78.82
Nitrogen	.30

Undoubtedly the value of muck in supplying organic matter, and thus improving the physical condition of our light, sandy soils, is too little appreciated. Muck, if sun-dried, will contain from 1 to 1.25 per cent. of nitrogen, and in addition serves as an excellent absorbent. In fact one ton of this sun-dried material contains practically one-third as much nitrogen as a ton of the average commercial fertilizers. The nitrogen in this form is, to be sure, not so quickly available as in ordinary fertilizers, but its effectiveness may be decidedly increased by the application to the soil in connection with it of air-slacked lime and wood-ashes, or by previous composting with these materials.

ANALYSES OF WATER SENT FOR EXAMINATION.

(PARTS PER MILLION).

Number.	Party Sending, and Locality.	Date of Analysis.	Free Ammonia.	Albumenoid Ammonia.	Chlorine.	Remarks.†
202	C. H. Coggeshall........Bristol.	Jan. 19.	.01	.05	20.00	Good.
203	L. J. Winsor ....Summit.......	Mar. 14.	.04	.07	11 50	Good.
204	W. A. Reynolds.........Davisville......	Sept. 3.	*	...	13.00	Very bad.
205	Eugene Hazard..........Peacedale....(well-water)..	Dec. 5.	.04	.07	12.00	Fair.
206	Eugene Hazard..........Peacedale ...(spring-water)	Dec. 5.	.04	.07	9.00	Questionable.

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* The amount of free ammonia in this sample was so large that it gave an extremely marked reaction even without distillation, consequently its determination and that of albumenoid ammonia was deemed unnecessary.

† The remarks in relation to the quality of the water are frequently based not only upon the figures contained in the table but upon observations in the course of the analyses, the presence of nitrates, etc , as well as upon data concerning the location of the well as regards the proximity of cesspools and other sources of contamination.

FIELD AND POT EXPERIMENTS.

A large portion of the time of the chemist has been occupied during the past year in planning and executing field and pot experiments with plants, which have been conducted in co-operation with the Agricultural Division. This work has been along the following lines, namely: 1. Further observations upon the use of lime in overcoming the ill-effect of sulphate of ammonia in connection with oats, and the subsequent effect of the treatment upon the relative growth of sorrel and clover. 2. Observations for the purpose of determining if the results secured in soil tests with a given plant are applicable to plants in general. 3. Observations upon the growth of about fifty agricultural plants upon an upland acid soil before and after liming. 4. Further investigation upon the effect of soil conditions upon the development of the potato scab. 5. Upon the relative value of the different forms of nitrogen used with and without lime. 6. Experiments to determine if soda has any value as a fertilizer in connection with, or as a substitute for, potash. 7. A test of the effect of the various alkalies upon the growth of beets on an acid soil.

CORRESPONDENCE, PUBLICATIONS, ETC.

The number of inquiries for information and advice in relation to farming operations involving agricultural chemistry has been decidedly greater during 1894 than in any previous year. The work in this line has been further increased owing to special work on the investigation of methods of potash analysis.

The publications issued during the year are the following: Bulletin 28, July, 30 pp., "Rhode Island Soils," "Fertilizers," by H. J. Wheeler and B. L. Hartwell. Bulletin 29, October, 14 pp., "Commercial and Special-Formula Fertilizers," by H. J. Wheeler and B. L. Hartwell. Bulletin 30, November, 30 pp., "Fertilizers," by H. J. Wheeler and B. L. Hartwell, and "Potato Scab," by H. J. Wheeler, J. D. Towar and G. M. Tucker. With the exception of the article on the investigation of potash methods previously mentioned and an abstract of the same for the *American Fertilizer*, the other articles prepared for publication, aside from those in the above-mentioned bulletins, may be found elsewhere in this report.

An exhibit illustrating the results of some of the experimental work conducted in conjunction with the Agricultural Division was made both at the Washington County and the State Fairs.

During the year a Soxhlet apparatus for starch determinations as well as several minor additions have been made to the outfit of the laboratory.

The need of more room, attention to which has been called in former reports, is greater now than ever before, not only for the purpose of conducting the work economically but also for carrying on special work which cannot be done in our present overcrowded quarters.

On July 1st, Mr. Charles L. Sargent, a graduate of the R. I. College of Agriculture and Mechanic Arts, was engaged as second assistant chemist. This move was necessitated on account of the increasing chemical work of the Station and owing to the fact that the time of the chemist is now occupied with teaching geology in the College and in the execution of field and pot experiments, which were formerly not a part of his duties. Mr. Sargent had been employed at the Station during the two preceding summers and had already become more or less familiar with chemical work in certain lines. Mr. Hartwell has rendered valuable assistance not only in strictly chemical work of the Division but also in connection with the general work in which I have participated. He has taken an active part in everything pertaining to the welfare of the Station. I desire to express my thanks to both of the above-named gentlemen for the interest which they have shown in everything pertaining to the welfare of the Division and for the careful manner in which they have executed whatever has been assigned to them.

OBSERVATIONS FOR THE PURPOSE OF DETERMINING IF THE RESULTS SECURED IN SOIL TESTS WITH A GIVEN PLANT ARE APPLICABLE TO PLANTS IN GENERAL.

H. J. WHEELER, J. D. TOWAR, AND G. M. TUCKER.

Soon after the organization of the experiment stations, established under the provisions of the Hatch Act, the desirability of the inauguration by them of soil tests with fertilizers for determining the special requirements of soils was strongly advocated by Professor Atwater, and a definite plan[1] for co-operative experiments in this line was published and issued by the Office of Experiment Stations at Washington and also by the Storrs School Agricultural Experiment Station of Connecticut. The proposed plan involved the use of several plots of land; one was to be left unmanured, another one to receive potash, another nitrogen, and still another phosphoric acid; the remaining plots were designed to receive combinations of potash and nitrogen, potash and phosphoric acid, nitrogen and phosphoric acid, and finally the last plot a combination of all three elements. By the effect of these elements upon the growth of the particular plant selected for the purpose, conclusions were to be drawn as to what elements were chiefly lacking in the soil; for example, if potash, when applied singly or in combination with other elements proved more beneficial than either of the other elements when similarly applied, then it is safe to assume that the soil stood chiefly in need of potash. Such soil tests have been conducted extensively in Connecticut, Massachusetts, Rhode Island, and other states.[1] In some instances they have failed to show the needs of the soils in a decided and satisfactory manner, but in such cases the failure has been due to inequalities in the fertility of the land which were not first ascertained, to drought, or to the fact that the soil already contained such an abundance of available fertilizing elements that any further application failed to increase the yield. In some instances also fully decisive results have not been obtained for the reason that enough of some particular element for the production of one or two successive crops was already present in available form, but in such cases most satisfactory conclusions as to the actual soil requirements have been obtained by a continuation of the experiment.

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[1] As published by the Office of Experiment Stations a plot upon which plaster was to be used was also included.

One of the earliest propositions for arriving at the same end was to submit the soil to chemical analysis, with the idea that if an abundance of certain elements was found by this means their application to the soil would be unnecessary. It need hardly be stated that this means of ascertaining the needs of more or less exhausted soils has proved disappointing. The reason for this may be briefly stated. The rootlets of plants have been found to be acid at their extremities, and it is certain that by their acid or other action they are enabled to extract a greater quantity of fertilizing material from the soil than would be removed by water or even water charged with carbonic acid, which is a normal constituent of the water of soils. The mineral acids exert as a rule a greater solvent action upon soils than do plants themselves. It is furthermore an extremely difficult matter to find an organic acid or other solvent which will extract from a given soil exactly the same amount of plant food as the plant itself would have removed.

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[1] The results of these tests may be found in the Experiment Station reports and bulletins of the respective states.

The difficulty is also further magnified in view of recent experiments which tend to show that the power of different plants of appropriating food from the soil is varied. And, furthermore, the rate at which the natural fertilizing constituents of the soil would become available by natural processes is not constant, but depends upon the individual character of the soil.

Another means for determining the fertilizer requirements of soils is based upon early investigations by Hellriegel[1] and the subsequent works of others, the results of which have led to the assumption that if an abundance of a given element is present in the soil in an available form its percentage in the plant will not be increased[2] by any further application to the soil, while, on the other hand, if the amount of a given ingredient is increased in the plant by the application of this ingredient to the soil, its need is thus ascertained. According to Helmkampf,[3] by establishing in this manner the minimum percentage of the elements which a given plant needs for its normal development, nothing would remain but to analyze a crop grown upon a particular soil, and from the percentage of the various elements in the dry matter of the plant, draw conclusions as to what particular elements are lacking in the soil. Heinrich employed for analysis the roots of plants, and others have analyzed, in work bearing on this question, the various parts of plants separately.

Summer wheat harvested while in bloom appears to be, of the plants with which Helmkampf has experimented, that best adapted to this particular purpose. According to the above-mentioned observer, quite satisfactory results have been obtained by these means. Cooke[4] concludes that the method of plant analysis for determining the needs of the soil is unreliable, yet his experiments were so limited in number that the drawing of general conclusions on his part as to the unreliability of the method appears hasty and unsupported by sufficient data; and in consideration of the results arrived at, especially by Helmkampf and others, there may be hope that this method for ascertaining the fertilizer requirements of soils may yet prove of some value. At all events the reliability of this method of determining the needs of all kinds of soils, in connection with the numerous kinds of plants grown, is at the present time far from being established, and since it involves chemical analysis it is incapable of application by the farmer himself.

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[1] Landw. Versuchs-stationen. Vol. xi., p. 136.

[2] Heinrich claims, however, that plants may take up elements in excess of their requirements.

[3] Journal f. Landw. 40. 1892. pp. 85 to 183.

[4] Bulletin 15, Vermont Agr. Expt. Sta., June, 1889. pp. 13 to 15.

Another means of ascertaining the needs of soils has been under investigation for a number of years by Ville[1] in France. He claims that evidence in this direction is afforded by the amounts of certain coloring matters produced in the plants themselves, and an extensive study of the best methods of estimating and comparing these colors has been made. The practical outcome of his observations is expressed as follows: "A dark green foliage indicates an ample supply of nitrogen in the soil." "A light green may indicate a soil lacking in nitrogen or in potash." "Intermediate shades between deep and pale green generally indicate a want in all the elements of fertility, while a somewhat darker green points to a lack of phosphoric acid." The practical applicability of this method to the end in view is probably as yet unestablished and is doubtless beset with difficulties in the way of occasional abnormal soil conditions. Finally, then, it may be asserted that the most satisfactory means of ascertaining the actual needs of our worn-out soils appears, at present, to be that afforded by soil tests with fertilizers and observations upon the resulting growth of the plants employed. Most of the soil tests thus far conducted in this country have been confined to the employment of a limited number of plants, and in some cases to the change involved in an annual rotation. The practice of employing a considerable variety of plants in experiments calculated to establish general principles bearing upon the manuring of plants is doubtless too infrequent and liable to lead to totally false conclusions. In view of experiments conducted by Wagner and Dehérain, which have shown that the feeding power, or in other words, the solvent action of the rootlets, of different plants upon the more insoluble potash and phosphoric acid compounds of the soil is a varying one, the question naturally suggested itself—if the results obtained in a soil test with fertilizers by the aid of a given plant would be equally applicable to all other plants. When we remember that a chemical analysis shows frequently an abundance of certain elements in the soil, which are nevertheless not immediately available, this individual feeding or dissolving power of plants assumes greater interest. It appeared possible that a certain plant might possess the ability in a high degree of appropriating potash, even though it was unable to appropriate phosphoric acid to any considerable extent. That plants with exactly opposite tendencies towards these two elements might also exist, seemed possible. If such differences were found to exist in any marked degree, it would then be obvious that the results secured in a soil test with any given plant would not be worthy of general application to plants, irrespective of their character. The experiment which we are about to describe was designed to test this particular point. The plots which served for this purpose had been used previously for soil tests with Indian corn for four consecutive years.[1] The fertilizing constituents employed in this experiment have been nitrate of soda, dissolved bone-black, and muriate of potash. The amounts of these applied per acre annually in 1890 and 1891, whether singly or in combinations of two or three, were as follows[2]: Nitrate of soda, 150 lbs.; dissolved bone-black, 350 lbs.; and muriate of potash, 130 lbs.

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[1] W. A. McDonald in *Am. Agriculturist*, Feb., 1894, pp. 61-62.

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[1] See Annual Reports R. I. Agl. Expt. Sta. from 1890 to 1893 inclusive.

[2] There was one exception to this treatment of the plots, viz : Previous to 1894 plot 7 had received but one-third the amount of nitrate of soda above mentioned, but in 1894 the full amount of 480 lbs. per acre was applied. It should also be noted that one-third of plot 7 received in 1893 air-slacked lime at the rate of 2⅓ tons per acre, and in 1894 the portion previously limed, as well as sufficient additional area to equal one-half of the plot, received a dressing of lime applied in such rates that the lime upon the half of the plot in question amounted in all to a *uniform* application of three tons per acre.

In 1893 and 1894 the amounts were increased to the following: Nitrate of soda, 480 lbs.; dissolved bone-black, 600 lbs.; muriate of potash, 200 lbs. The first year of the experiment (1890) phosphoric acid did not appear to be more deficient than potash, yet from the second and succeeding years of the test, phosphoric acid appeared to be unquestionably the element which was chiefly lacking, though potash and nitrogen were evidently also lacking in a measure. The results gave very conclusive evidence that the amount of readily available phosphoric acid was practically exhausted by the first crop—namely, that of 1890. Indian corn had been employed in this test for the four years, 1890 to 1893 inclusive. In 1894 thirty-seven varieties of plants were grown across these plots, and the length of the plots was sufficient to allow of two rows for each variety. The plots were therefore practically divided in the centre, the relative arrangement of the rows of the different varieties of plants being the same on both sides. By this arrangement the duplicate rows were separated from each other in every case by a distance equal to one-half of the length of the plots, or by more than one hundred feet. The soil was in such an extremely exhausted condition that the application of two elements only rarely produced a good crop, and with many of the crops grown it will be seen that where phosphoric acid was lacking the yield was practically nothing, even though sufficient nitrogen and potash was applied.

Table I, which follows, gives the weights of the crops secured on the various plots, and Table II, which succeeds it, gives an idea of the relative date and maturity of a few plants upon the different plots, the products of which were harvested at intervals, as they ripened.

TABLE I.—SHOWING THE WEIGHTS,* IN OUNCES, OF THE DIFFERENT CROPS AT THE TIME OF HARVESTING.

NAME OF CROP.	PLOT NO. 1. — Nitrate of Soda, 24 lbs.		PLOT NO. 2. — Dissolved Bone-black, 30 lbs.		PLOT NO. 3. — Muriate of Potash, 10 lbs.		PLOT NO. 4. — Nitrate of Soda, 24 lbs. Dissolved Bone-black, 30 lbs.		PLOT NO. 5. — Nitrate of Soda, 24 lbs. Muriate of Potash, 10 lbs.		PLOT NO. 6. — Dissolved Bone-black, 30 lbs. Muriate of Potash, 10 lbs.		PLOT NO. 7. — Dissolved Bone-black, 30 lbs. Muriate of Potash, 10 lbs. Nitrate of Soda, 24 lbs.	
	North and South rows.†	Average of rows.	North and South rows.	Average of rows.	North and South rows.	Average of rows.	North and South rows.	Average of rows.	North and South rows.	Average of rows.	North and South rows.	Average of rows.	North row unlimed.	South row limed.
Clover, Crimson	53.0 5.0	29.0	35.0 30.0	32.5	29.0 8.0	18.5	42.0 53.0	47.5	85.0 18.0	51.5	34.0 43.0	38.5	69.0	102.0
Pea, American Wonder	1.5 0.3	0.9	5.3 2.3	3.8	1.0 0.3	0.7	5.5 2.0	3.8	1.5 0.3	0.9	2.0 0.5	1.3	6.5	10.3
Bean, White	2.0 0.5	1.3	5.0 3.0	4.0	6.0 6.0	6.0	10.0 4.0	7.0	10.0 6.0	8.0	11.0 10.0	10.5	21.0	17.0
Cowpea	118.0 70.0	94.0	116.0 128.0	122.0	132.0 80.0	106.0	212.0 228.0	220.0	168.0 140.0	154.0	320.0 324.0	322.0	336.0	356.0
Soja Bean	136.0 40.0	88.0	124.0 136.0	130.0	101.0 40.0	70.5	188.0 148.0	168.0	188.0 48.0	118.0	224.0 140.0	182.0	368.0	328.0
Lupine, Blue	0.5 6.0	3.3	8.0 2.0	5.0	3.0 1.0	2.0	13.0 4.0	8.5	2.0 1.0	1.5	4.0 3.0	3.5	9.0	8.0
Barley	0.0 0.0	0.0	1.0 0.5	0.8	0.0 0.0	0.0	1.0 1.5	1.3	0.0 0.0	0.0	0.3 0.5	0.4	6.0	14.5
Oats	0.5 0.2	0.4	3.3 3.5	3.4	0.5 0.0	0.3	7.0 7.0	7.0	0.5 0.5	0.5	4.5 5.0	4.8	14.0	7.5
Rye	0.3 1.0	0.7	5.8 6.0	5.9	1.0 0.8	0.9	9.0 9.0	9.0	1.0 1.0	1.0	4.0 4.5	4.3	15.0	13.8
Wheat	0.1 0.0	0.1	1.5 0.5	1.0	0.0 0.0	0.0	0.5 1.0	0.8	0.1 0.1	0.1	0.5 1.0	0.8	1.8	4.8
Millet	12.0 0.0	6.0	38.0 64.0	51.0	3.0 0.0	1.5	60.0 44.0	52.0	3.0 4.0	3.5	48.0 60.0	54.0	124.0	160.0
Corn..... Ears	2.0 0.5	1.3	5.0 17.0	11.0	2.0 0.0	1.0	14.0 15.0	14.5	1.0 1.0	1.0	19.0 34.0	26.5	64.0	50.0
Corn..... Stover	18.0 5.5	11.8	27.0 39.0	33.0	18.0 8.0	13.0	42.0 45.0	43.5	15.0 15.0	15.0	87.0 62.0	74.5	58.0	124.0
Corn..... Total	20.0 6.0	13.0	32.0 56.0	44.0	20.0 8.0	14.0	56.0 60.0	58.0	16.0 16.0	16.0	106.0 96.0	101.0	122.0	174.0
Sorghum, Amber Cane	0.0 0.0	0.0	28.0 64.0	46.0	0.0 0.0	0.0	32.0 48.5	40.3	8.0 0.0	4.0	56.0 100.0	78.0	208.0	284.0
Sunflower	78.0 1.0	38.5	76.0 8.0	42.0	264.0 16.0	140.0	108.0 48.0	78.0	192.0 12.0	102.0	448.0 256.0	352.0	540.0	500.0

Beet, Mangel-Wurzel	0.0 0.0	0.0	11.0 0.0	5.5	0.0 0.0	0.0	2.0 0.0	1.0	0.0 0.0	0.0	12.0 0.0	6.0	12.0	344.0
Carrot, Danvers	186.0 0.0	68.0	104.0 16.0	60.0	186.0 0.0	98.0	88.0 62.0	75.0	88.0 0.0	44.0	216.0 18.0	117.0	256.0	182.0
Swedish Turnip, Budlong	0.0 0.0	0.0	94.0 16.0	55.0	1.0 0.0	0.5	164.0 76.0	120.0	0.0 0.0	0.0	165.0 96.0	130.5	152.0	328.0
Turnip, Flat	0.5 0.0	0.3	186.0 79.0	182.5	0.0 0.0	0.0	284.0 109.0	171.5	0.0 0.0	0.0	298.0 118.0	208.0	344.0	316.0
Radish, Long Scarlet	0.0 0.0	0.0	9.0 1.8	5.2	0.0 0.0	0.0	10.5 7.0	8.8	0.0 0.0	0.0	36.8 11.8	24.3	48.8	31.8
Parsnip	0.0 0.0	0.0	2.0 4.0	3.0	0.0 1.0	0.5	4.0 20.0	12.0	0.0 0.0	0.0	3.0 4.0	3.5	92.0	222.0
Onions... Red	0.0 0.0	0.0	1.0 2.0	1.5	0.0 0.0	0.0	4.0 7.0	5.5	0.5 0.5	0.5	8.0 88.0	48.0	7.0	48.0
Yellow	0.0 0.0	0.0	1.0 8.0	4.5	0.0 0.0	0.0	1.0 11.0	6.0	0.0 0.0	0.0	5.0 88.0	46.5	29.0	58.0
Salsify	0.0 0.0	0.0	0.0 10.0	5.0	0.0 0.0	0.0	3.0 32.0	17.5	3.0 0.0	1.5	3.0 20.0	11.5	18.0	54.0
Squash, Summer	17.0 0.0	8.5	0.0 0.0	0.0	80.0 12.0	46.0	30.0 4.0	17.0	25.0 0.0	12.5	52.0 5.0	28.5	6.0	202.0
Cucumber	0.0 0.0	0.0	21.5 15.0	18.3	0.0 3.0	1.5	18.0 14.5	16.3	0.5 4.5	2.5	26.0 32.5	29.3	405.0	282.0
Pumpkin	0.0 0.0	0.0	0.0 26.0	13.0	0.0 0.0	0.0	20.0 0.0	10.0	12.0 0.0	6.0	200.0 398.0	299.0	488.0	1010.0
Kohl Rabi	0.0 0.0	0.0	4.0 38.0	21.0	0.0 0.0	0.0	23.0 24.0	23.5	0.0 0.0	0.0	22.0 42.0	32.0	80.0	62.0
Cabbage	18.0 2.0	10.0	87.0 252.0	169.5	3.0 4.0	3.5	264.0 272.0	268.0	8.0 0.0	4.0	220.0 284.0	252.0	358.0	456.0
Cauliflower	0.0 0.0	0.0	0.0 4.0	2.0	0.0 0.0	0.0	0.0 20.0	10.0	0.0 0.0	0.0	30.0 148.0	89.0	228.0	351.0
Kale	0.0 0.0	0.0	20.0 115.0	67.5	0.0 0.0	0.0	208.0 188.0	198.0	0.0 0.0	0.0	180.0 224.0	202.0	276.0	552.0
Lettuce	0.0 0.0	0.0	7.0 0.0	3.5	0.0 0.0	0.0	3.0 0.0	1.5	1.0 0.0	0.5	10.0 0.0	5.0	32.0	88.0
Rape	0.0 0.0	0.0	104.0 48.0	76.0	0.0 0.0	0.0	100.0 128.0	114.0	0.0 0.0	0.0	144.0 118.0	131.0	596.0	612.0
Tomato	24.5 10.0	17.3	49.0 70.0	59.5	12.0 15.0	13.5	126.0 140.0	133.0	39.0 49.0	44.0	354.0 169.0	261.5	509.0	677.0
Pepper	2.0 0.0	1.0	2.0 2.0	2.0	6.0 0.0	3.0	4.0 8.0	6.0	2.0 0.0	1.0	25.0 24.0	24.5	40.0	48.0
Potato	49.0 20.0	34.5	49.0 48.0	48.5	44.0 17.0	30.5	52.0 64.0	58.0	52.0 12.0	32.0	78.0 80.0	79.0	112.0	100.0
Spinach, Round Leafed	0.0 0.0	0.0	0.0 0.0	0.0	0.0 0.0	0.0	0.0 0.0	0.0	0.0 0.0	0.0	0.0 0.0	0.0	0.0	27.5
Muskmelon	0.0 0.0	0.0	0.0 0.0	0.0	0.0 0.0	0.0	0.0 1.0	0.5	8.0 0.0	4.0	92.0 12.0	52.0	76.0	126.0

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* The weights represent, in the case of root crops, only the root portions; of all other crops, excepting the white bean, of which the beans only were weighed, and squash, cucumber, pumpkin, muskmelon, tomato and pepper, of which the fruit only was weighed, the portions above ground are recorded. This course was pursued because in many cases, owing to the impoverished condition of the soil, no fruit or grain was produced.

† The yields from the north row are printed above those from the south row.

TABLE II.—SHOWING THE COMPARATIVE SIZES AND DATES OF RIPENING OF CUCUMBERS, TOMATOES AND KOHL-RABI ON THE VARIOUS PLOTS.

	DATES WHEN HARVESTED.	PLOT No. 1. — Nitrate of Soda, 24 lbs.		PLOT No. 2. — Dissolved Bone-black, 30 lbs.		PLOT No. 3. — Muriate of Potash, 10 lbs.		PLOT No. 4. — Nitrate of Soda, 24 lbs. Dissolved Bone-black, 30 lbs.		PLOT No. 5. — Nitrate of Soda, 24 lbs. Muriate of Potash, 10 lbs.		PLOT No. 6. — Dissolved Bone-black, 30 lbs. Muriate of Potash, 10 lbs.		PLOT No. 7. — Mixed Minerals as in No. 6. Nitrate of Soda, 24 lbs.	
		Number.	Average weight—ounces.	Number.	Average weight—ounces.	Number.	Average weight—ounces.	Number.	Average weight—ounces.	Number.	Average weight—ounces.	Number.	Average weight—ounces.	Number.	Average weight—ounces.
CUCUMBERS.	July 30	....	....	....	....	....	....	....	....	....	....	2	1.0	7	2.3
	August 6	....	....	....	....	....	....	....	....	....	....	8	0.7	12	2.0
	August 14	....	....	4	2.5	....	....	4	1.3	....	....	6	1.2	19	2.1
	August 20	....	....	7	0.7	....	....	4	1.3	....	....	7	1.0	33	1.8
	August 25	....	....	2	0.3	....	....	5	0.2	....	....	7	....	28	1.0
	August 29	....	....	4	0.5	....	....	2	1.0	....	....	....	....	11	3.7
	September 7	....	....	4	0.5	....	....	2	2.0	....	....	3	0.7	28	2.7
	October 1	....	....	5	0.6	....	....	4	0.3	2	0.3	12	0.3	37	3.5
TOMATOES.	August 14	....	....	....	....	1	2.0	....	....	....	....	....	....	2	3.0
	August 20	....	....	6	1.0	....	....	15	1.5	2	1.0	....	....	9	2.6
	August 25	....	....	....	....	....	....	11	0.5	2	1.0	3	3.7	16	3.3
	August 29	....	....	6	1.2	....	....	10	1.9	3	1.3	9	3.5	16	3.9
	September 7	1	0.5	7	1.3	....	....	5	2.8	....	....	15	5.7	19	3.8
	September 27	6	2.7	....	....	....	....	8	1.5	5	3.2	9	3.1	31	2.6
KOHL-RABI.	August 6	....	....	....	....	....	....	....	....	....	....	....	....	3	3.0
	August 14	....	....	....	....	....	....	....	....	....	....	....	....	7	4.9
	August 20	....	....	....	....	....	....	1	3.0	....	....	2	3.0	4	3.0
	August 29	....	....	....	....	....	....	....	....	....	....	....	....	4	3.0
	September 1	....	....	....	....	....	....	....	....	....	....	1	3.0	1	3.0
	September 7	....	....	....	....	....	....	....	....	....	....	....	....	1	3.0
	September 24	....	....	....	....	....	....	....	....	....	....	5	1.6	2	3.5
	September 29	....	....	9	4.0	....	....	23	0.9	....	....	8	0.6	....	....

From a careful comparison of the results secured with the various crops enumerated in the foregoing Table (I.), it is evident in the case of the majority of them that phosphoric acid was unquestionably more deficient than either of the other elements. The same is true not only of the plots which received single elements only, but also of those plots where phosphoric acid was used in connection with either nitrogen or potash. It will also be noticed in most of those cases where the lack of phosphoric acid was so extremely marked that the results secured with the duplicate rows accord satisfactorily. Those plants which have shown decidedly that phosphoric acid was the element most deficient in the soil are the following:

American Wonder Pea,
Blue Lupine,
Barley,
Oats,
Rye,
Wheat,
Millet,
Indian Corn,
Sorghum (amber cane),
Mangold-wurzel Beet,
Swedish Turnip,
Flat Turnip,
Radish,
Parsnip,
Red Onion,
Yellow Onion,
Salsify,
Cucumber,
Pumpkin,
Kohl Rabi,
Cabbage,
Kale,
Lettuce,
Rape,
Tomato,
Pepper,
Potato,
Muskmelon,
Cauliflower.

It will be observed by comparison of the results with both single elements and combinations of two, that the white bean, sunflower and the summer squash were evidently more benefited by potash than by phosphoric acid. With no kind of plants was nitrogen shown to be the most deficient element.

Another interesting feature is observable in connection with those plants which showed that phosphoric acid was most deficient, namely, the results with some of them indicate that potash was less deficient than nitrogen, while others indicate that nitrogen was less deficient than potash. Those plants just mentioned that showed a greater deficiency of potash than of nitrogen are the following:

Indian Corn,
Sorghum,
Flat Turnip,
Red Onion,
Yellow Onion,
Cucumber,
Pumpkin,
Tomato,
Pepper,
Potato,
Muskmelon,
Cauliflower,
Cow Pea.

The following are those plants which showed a greater deficiency of nitrogen than of potash:

American Wonder Pea,[1]
Blue Lupine,[1]
Barley,
Oats,
Rye,
Millet,
Parsnip.

In the case of a number of plants which showed unquestionably which element was most deficient, the relative deficiency of the other elements was not apparent. The duplicate rows of crimson clover and soja bean furnished such conflicting results that no conclusions whatever could be drawn. So far as concerns crimson clover the negative result was undoubtedly attributable to the fact that the north row was on the border of the field where it may have drawn nourishment from the adjoining land. The spinach positively refused to grow except on the limed portion of plot 7, even though supplied with an abundance of phosphoric acid, potash and nitrogen. This was doubtless due to the acidity of the soil, which affected the spinach more seriously than any other crop. The lettuce for the same reason produced only a minimum growth except where limed.

SUMMARY.

The results of the foregoing experiment indicate that the conclusions drawn from a soil test with a given plant may not apply to all others regardless of their character. The results show in a

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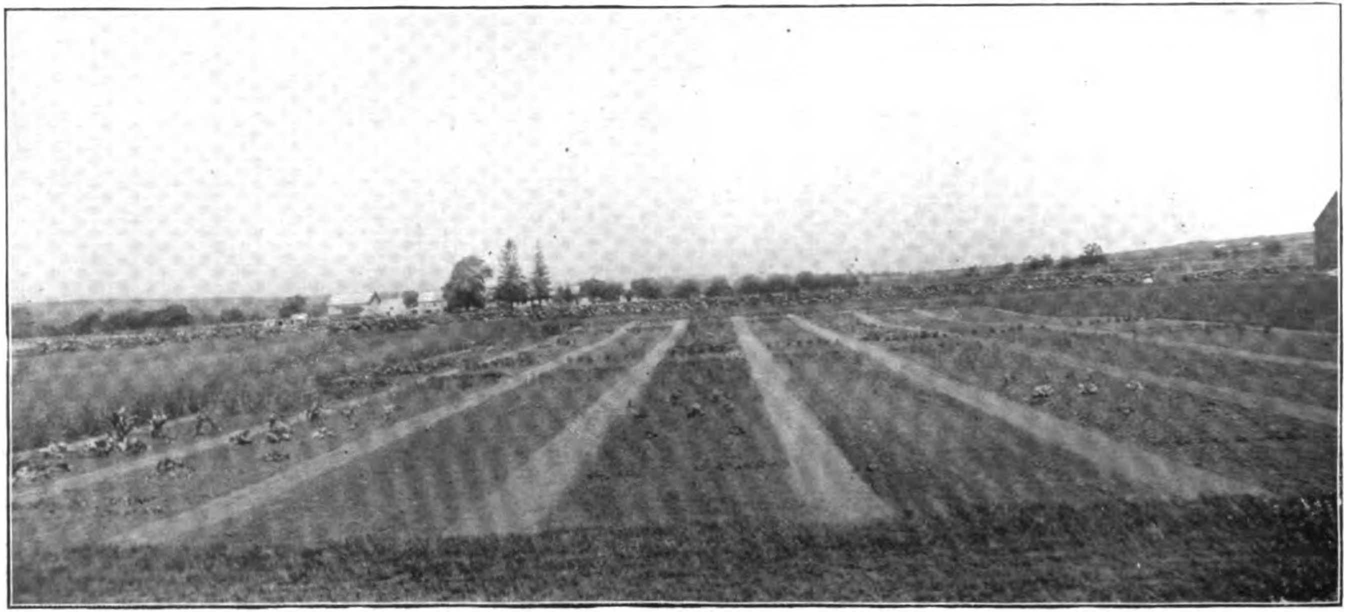
[1] Lupines and peas, as far as we are aware, had never been grown previously upon this soil, and the organisms by which they are enabled to get their nitrogen from the air were probably few or wholly lacking, which explains the greater beneficial action of the nitrogen as compared with the potash.



Plot 7.
Phos. Acid, Potash, and Nitrogen.
Lime in foreground.

Plot 6.
Phos. Acid and Potash.

Plot 5.
Nitrogen.

Plot 4.
Phos. Acid and Nitrogen.

Plot 3.
Potash.

Plot 2.
Phos. Acid.

Plot 1.
Nitrogen.

Plot 0.
No Manure.

SOIL TEST.

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very marked manner that the majority of plants with which we have experimented indicate a deficiency of available phosphoric acid in the soil, and it is possible that any one of these may be used for determining the fertilizer requirements of the others as far as concerns phosphoric acid.

Another noteworthy feature of the results is that those plants which show an unquestionable lack of assimilable phosphoric acid in the soil do not agree among themselves as to the relative deficiency of potash and nitrogen.

The most interesting point brought out by the experiment is that a soil shown by the cereals and many other plants to be exceedingly deficient in phosphoric acid should, when tested with certain other plants, appear to be chiefly deficient in potash.

It will be evident from the foregoing that a test of the soil in question by means of the white bean or sunflower might have led to wholly erroneous conclusions as to the element most needed for the production of the greater portion of our ordinary crops.

In the experiment of this year so large a number of plants was employed that only two rows of each could be grown, consequently the results are not so conclusive as they would otherwise have been ; in fact, the experiment was only intended as a preliminary one for the purpose of obtaining indications upon which more extended experiments could be based. It is hoped the coming season to employ on a larger scale those plants which showed potash to be chiefly deficient, and one or two which gave conclusive evidence of a lack of assimilable phosphoric acid. Certainly at present it appears doubtful if conclusions from a soil test with a certain plant are worthy of universal application, and the desirability of further investigation in this line seems evident.

OBSERVATIONS UPON THE GROWTH OF VARIOUS PLANTS UPON AN UPLAND ACID SOIL BEFORE AND AFTER LIMING.

H. J. WHEELER, J. D. TOWAR, G. M. TUCKER.

This experiment was conducted upon Nos. 23, 25, 27 and 29 of the permanent experimental plots. The general plan and arrangement of these plots has been given in detail in the Fourth Annual Report of this Station for 1891, pp. 13–15, and in the Sixth Annual Report for 1893, p. 225. Prior to 1891 the land had been in grass for a number of years and considerable moss was visible over the surface. The land consists of sandy loam underlaid by alternating layers of sand and gravel, which afford good natural drainage. In 1891, a crop of beans, and, in 1892, Indian corn, had been grown without manuring to ascertain if the plots were sufficiently uniform for comparative experiments, which was found to be the case. In 1893 the four plots received a uniform dressing of potash and phosphoric acid at the rate of 200 lbs. of muriate of potash and 600 lbs. of dissolved boneblack per acre. The two plots towards the west, 23 and 25, received in addition a dressing of nitrogen in the form of sulphate of ammonia at the rate of 360 lbs. per acre, and the two plots towards the east, 27 and 29, received 465 lbs. of nitrate of soda, which furnished nitrogen at the same rate as the sulphate of ammonia upon the other plots. One of the nitrate of soda (25) and one of the sulphate of ammonia plots (29) received as a further addition a dressing of air-slacked lime at the rate of 5400 lbs. per acre. The lime was sown broadcast upon the furrows in the spring and thoroughly harrowed in.

In 1894, potash, phosphoric acid and nitrogen were applied at the same rate and in the same form upon the respective plots as in 1893. Owing to the fact that in the autumn of 1893 the plots which had received a dressing of lime were still somewhat acid, a further application of half a ton per acre was made in the spring of 1894 to plots 25 and 29, which had been limed the preceding year. The seed and the young plants of the various kinds employed were sown or set, as the case might be, in a uniform manner across the four plots. Very careful observations were made for the purpose of ascertaining if the seeds germinated equally well upon all of the plots, and such was found to be the case. In the case of the beets, spinach, lettuce, and a few other crops, the young plants soon presented a yellow, sickly appearance, and upon plot 27 many, and upon plot 23 practically all, of them died before the time when the second or third leaves should have appeared. From this it will appear that whatever the injurious substances in the soil may have been, they must have been present near the surface of the soil, or otherwise the young plants, which had not yet sent their roots to any considerable depth, would not have been affected. The cause of the acidity of the soil appears to be organic acids or acid compounds of the same, which are commonly referred to as "sour humus." The soil has been examined on several occasions for proto-sulphate of iron, which, according to Voelcker[1] and others, is a frequent cause of the sterility of soils. In no instance has even a trace of proto-sulphate of iron been found. It is the intention of one of us to test the soil chemically in other directions to ascertain more definitely, if possible, if the peculiar conditions are, as has been supposed, actually due to the presence of unneutralized organic acids, or to the existence of still other compounds, the presence of which has not suggested itself. One fact has been fully established—that sulphate of ammonia, if not applied in connection with lime or other substances capable of reducing or overcoming the natural acidity of the soil,[1] further increases the injurious action upon the growth of most of our agricultural plants. Whether this is due to the presence of untransformed sulphate of ammonia in the soil or to the liberation of free sulphuric acid[2] from the sulphate of ammonia itself, as has been noted by Mulder[3] in the action of humic acid upon proto-sulphate of iron, has not been determined. Either of these results would probably be due to the acidity of the soil and to the absence of compounds capable of changing the sulphate of ammonia into a form suitable for nitrification. It has already been stated in a prévious publication[4] that a similar ill effect from the use of sulphate of ammonia had been observed on a sandy loam soil in Hope Valley, R. I. This, together with the fact of the lesser value of sulphate of ammonia as compared with nitrate of soda in other portions of the State, and also the recognition of a greater or less degree of acidity of many soils in this State and other parts of New England, indicates that soil conditions analogous to our own exist to a greater or less extent. Extended reference has already been made in the publication above referred to concerning the observations upon the ill effect of sulphate of ammonia which have been made in Europe. In an experiment[5] by Goessmann, we have noticed that there was apparently an ill effect from sulphate of ammonia in certain instances on the growth of winter rye during the earlier part of the season, as shown by the comparative height of the crop at different periods. In another experiment[6] conducted in a greenhouse, in which sandy loam subsoil was employed, the less effect of nitrogen in form of sulphate of ammonia as compared with that of nitrate of soda is noticeable in the case of lettuce, beets and tomatoes, but where used in connection with muriate of potash, sulphate of potash, and carbonate of potash and magnesia, respectively, a smaller difference between the effectiveness of the two forms of nitrogen existed where carbonate of potash and magnesia was used than where either sulphate or muriate of potash was employed. So far as concerns the spinach, the data given furnished no evidence as to the relative effectiveness of the nitrogen in the two forms, nor as to the relative degrees of effectiveness where the different forms of potash were employed with it. Though the statement is made that the results secured with the carbonate of potash and magnesia were superior to those obtained with the other forms of potash, he offers no explanation for the greater efficiency of the carbonate of potash and magnesia as compared with the other potash salts, nor does he call attention to the fact that the effectiveness of the sulphate of ammonia more nearly approaches that of the nitrate of soda when used with the carbonate of potash and magnesia than when used with the muriate or sulphate of potash. Our own observations upon the acid soil of Kingston Plain, especially upon the growth of beets, lettuce and spinach, lead us to the assumption that the soil employed by Goessmann must have been acid to some extent or that it contained materials noxious to vegetation, the injurious effects of which were overcome to a greater or less extent by the carbonate of potash and magnesia which would exert an alkaline influence upon the soil. If the former of the above conditions prevailed the smaller difference in the effectiveness of the two forms of nitrogen when employed in connection with the carbonate of potash and magnesia finds its ready explanation in the fact that acidity beyond a certain extent delays the nitrification of the ammonia salt and reduces its consequent effectiveness. That the acidity of the soil may have had a bearing upon the results has been left entirely out of consideration by Goessmann. The serious injury of a certain crop by the application of sulphate of ammonia upon a field in the vicinity of Hadley, Mass., has been called to our attention by Mr. G. D. Howe of North Hadley. We have been informed of a practical failure in the cultivation of certain garden crops in a greenhouse where surface soil from a field had been employed, and the injurious effects were wholly overcome by lime in the carbonate or caustic state. Prominent Rhode Island market-gardeners have, without ascertaining the reason, found that lime in connection with subsoil is highly beneficial to the growth of cucumbers in the greenhouse.

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[1] Jour. Royal Agricultural Society, England, 1865, p. 115.

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[1] Sixth Annual Report R. I. Agl. Expt. Sta., 1893, p. 206.

[2] Farsky (Biedermann's Central-Blatt, 1886, p. 453) has shown a direct application of sulphuric acid to the soil to be injurious to vegetation.

[3] Chemie der Ackerkrume, Vol. II, p. 37.

[4] Sixth Annual Report R. I. Agl. Expt. Sta., 1893, pp. 222-224.

[5] Ninth Annual Report Mass. Agl. Expt. Sta., 1891, p. 175.

[6] Eleventh Annual Report Mass. Agl. Expt. Sta., 1893, pp. 241-254.

Our object in calling attention to the ill and occasional less effect of sulphate of ammonia, and to the beneficial action of the carbonate of potash and magnesia in increasing its effectiveness more than that of nitrate of soda, is merely to emphasize the fact that the acidity of soils, which is not generally supposed to exist to an injurious extent except in swamps and very wet lands, is probably not infrequently met with on upland and well-drained soils which have not received barnyard manure, wood-ashes, lime or other alkaline treatment; and that in all probability the question of acidity has been too generally ignored in the examination of soils. Attention has been called by Müntz and Girard[1] to the beneficial action of lime upon the acid soils of Brittany and Limousin, which are of granitic origin and resemble in this respect most of the soils of Rhode Island. Dehérain[2] also calls attention to the benefit derived from the use of lime in Limousin, France. He states that the culture of clover, which was formerly unknown, was rendered possible by the use of lime, and attributes to its action the transformation of this country, which had been in a miserable state for centuries, to a state of prosperity. In a recent article Pichard[3] states that on the sandy soils of Brittany, which are said to be poor in assimilable potash and which are extremely deficient in lime but rich in organic nitrogen (humus), the addition of lime raised the yield of fodder beets from 6,315 kilogrammes to 21,627 and 38,700 kilogrammes per hectare, and plaster used with the lime still further increased the yield. Although no special mention of the physical character of the soils of Limousin and Brittany is made, it would appear that they must have been, in general, upland or naturally well-drained soils and not swampy lands. Those crops which in Limousin and Brittany are mentioned as being benefited by lime are fodder beets, rutabagas, potatoes, the cereals, and, more particularly, clovers and other legumes.

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[1] Annales Agron. 17, 1891, p. 299.

[2] Traité de Chimie Agricole, Paris, 1892, p. 531.

[3] Comptes Rendus, Vol. 119, No. 10, Sept. 3, 1894, p. 473.

So far as we are aware no one has heretofore made a special study of the effect of lime upon any considerable number of plants, though Braungart[1] has made extensive observations upon the kinds of plants which grow naturally upon soils of various character. The results secured during 1894, the second year[2] of the experiment, are embodied in the following tables. The crops in Table I are arranged in regular order according to the benefit derived from the use of lime in connection with nitrate of soda as shown by the gain upon plot 29 over the yields of plot 27. The numbers in the last two columns were obtained by dividing the individual yields upon plot 29 by those upon plot 27, and represent the degree of gain or loss by the use of lime upon nitrate of soda for the years 1893 and 1894. Plots 27 and 29 were the only two that could furnish a proper basis for judging of the direct manurial effect of the lime and of its action in overcoming the acidity of the soil. This is due to the fact that the nitrogen was in a form directly available to the plants, while upon the sulphate of ammonia plots, 23 and 25, the benefit from the lime was probably due not only to the above-mentioned causes, but also to the fertilizing action of the nitric acid produced by the nitrification of the ammonia. Those crops, concerning which no data are given in the last column of Table I, were not grown in 1893.

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[1] Jour. f. Landw., 1879, pp. 423–481; also, Jour. f. Landw., 1880, pp. 94-155, 399-469.

[2] See also Sixth Annual Report R. I. Agl. Expt. Sta., 1893, pp. 224-252.

TABLE I.

PLOT No	23	25	27	29	Relative yields on Plot 29, reckoning those on Plot 27 as 1.	
FERTILIZERS APPLIED.						
Dissolved Boneblack.........Lbs. per acre....	600	600	600	600		
Muriate of Potash........ " "	180	180	180	180		
Sulphate of Ammonia........ " "	360	360	....	....		
Nitrate of Soda........ " "	....	....	465	465		
Air-slacked Lime, during two years... " "	....	6400	....	6400		
NAMES OF CROPS.*	Lbs. per row.	Lbs. per row.	Lbs. per row.	Lbs. per row.	1894	1893
1. Spinach	0.0	2.2	0.1	6.1	61.00	24.75
2. Gumbo	0.0	20.0	2.1	23.8	11.33	.....
3. Sugar Beet	0.0	25.0	3.0	33.0	11.00	12.17
4. Lettuce	0.0	3.1	0.6	6.0	10.00	77.93
5. Salsify—(roots)	0.0	8.4	1.0	9.5	9.50	.....
5. Salsify—(whole plant)	0.0	24.5	2.5	27.0	.....	.....
6. Celery	0.8	23.0	4.3	40.5	9.42	.....
7. Onion—red	0.0	8.0	2.0	18.0	9.00	.....
8. Globe Mangel-wurzel	0.0	23.8	5.3	43.5	8.21	10.75
9. Onion—yellow	0.0	8.5	1.6	13.0	8.12	.....
10. Parsnip—(roots)	0.0	31.3	4.8	33.5	6.99	.....
10. Parsnip—(whole plant)	0.0	46.5	6.8	49.8	.....	.....
11. Long Mangel-wurzel—(roots)	0.0	34.3	16.8	97.0	5.77	7.59
11. Long Mangel-wurzel—(tops)	0.0	16.8	10.5	38.0	.....	.....
12. Table Beets	0.0	40.0	11.5	61.5	5.35	4.22
13. Muskmelon—(fruit)	0.0	29.9	7.1	33.4	4.70	.....
14. Cabbage—late	1.0	67.2	26.8	123.3	4.60	2.37
14. Cabbage—late—(trimmed heads)	0.0	34.6	7.0	71.0	.....	.....
15. Tobacco	1.8	33.3	9.5	43.0	4.52	.....
16. Egg Plant—(fruit)	2.3	1.8	4.0	15.1	3.75	.....
17. Cauliflower	0.3	74.6	19.8	70.1	3.70	.....
17. Cauliflower—(heads)	0.0	1.8	1.8	3.5	.....	.....
18. Cucumber—(fruit)	0.7	36.1	28.9	87.3	3.02	.....
19. Sorghum	0.0	58.4	23.6	70.5	2.99	10.55
20. Martynia	1.0	22.5	17.8	50.6	2.84	.....
20. Martynia—(seed and pods)	0.3	7.8	5.4	17.8	.....	.....

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* The figures represent, in the case of the root crops, the weights of the roots only, and in all other cases the whole plant above ground, unless otherwise stated.

TABLE I.—*Continued.*

PLOT No		23	25	27	29	Relative yields on Plot 29, reckoning those on Plot 27 as 1.	
FERTILIZERS APPLIED.							
Dissolved Boneblack	Lbs. per acre	600	600	600	600		
Muriate of Potash	" "	180	180	180	180		
Sulphate of Ammonia	" "	360	360	....	....		
Nitrate of Soda	" "	....	....	465	465		
Air-slacked Lime, during two years	" "	....	6400	....	6400		
NAMES OF CROPS.*		Lbs. per row.	Lbs. per row.	Lbs. per row.	Lbs. per row.	1894	1893
21.	Pepper—(fruit)	0.1	4.5	2.3	6.3	2.74	.....
	Pepper	0.2	5.8	3.2	10.0	.....	.....
22.	Peanut	3.8	3.3	3.5	8.9	2.58	.....
	Peanut—(nuts)	1.1	1.1	1.8	1.2	.....	.....
23.	Barley—(air-dried) †	0.1	3.6	1.8	3.7	2.06	1.80
24.	Rape	0.0	97.8	58.0	114.4	1.97	.....
25.	Red Clover—(air-dried)	0.2	9.5	4.1	7.0	1.70	.....
26.	Potato—Beauty of Hebron—(tubers)	5.2	23.4	16.5	27.7	1.67	.....
27.	Garden Peas	0.1	13.7	8.0	14.2	1.65	1.53
28.	Kohl Rabi	0.5	9.3	5.9	9.4	1.59	.....
29.	Brussels Sprouts	6.3	95.3	64.6	101.4	1.57	.....
	Brussels Sprouts—(sprouts)	0.5	6.5	4.1	5.0	.....	.....
30.	Golden Wax Bean—(beans and pods)—ripe	0.0	3.3	2.4	3.8	1.58	.....
31.	Buckwheat—(air-dried)	0.8	5.5	3.8	5.8	1.53	1.65
32.	Rutabaga or Swedish Turnip	1.5	59.8	45.5	66.5	1.46	1.83
33.	Tomato—(fruit)	13.9	170.9	157.8	215.2	1.42	1.40
	Tomato—(vines)	6.5	42.5	40.0	62.5	.....	.....
34.	Sunflower	0.8	69.3	59.3	84.0	1.42	1.09
35.	Spring Wheat—(air-dried)	0.1	0.8	0.5	0.7	1.40	.....
36.	Radish—Long Scarlet	0.6	1.8	4.6	6.3	1.37	.....
37.	Turnip—Purple Top	2.5	35.5	33.0	44.0	1.29	.....
38.	Cabbage—Early	11.1	116.6	84.8	105.3	1.24	1.28
	Cabbage—Early—(trimmed heads)	2.0	71.3	55.3	68.1	.....	.....
39.	White Carrot	0.0	13.4	16.4	19.4	1.18	1.76
40.	Turnip—Early Red Top	2.5	34.8	32.0	37.0	1.15	.....
41.	Kale	9.4	95.0	64.8	94.4	1.15	1.51

* The figures represent, in the case of the root crops, the weights of the roots only, and in all other cases the whole plant above ground, unless otherwise stated.

† Dried for several weeks under cover.

TABLE I.—*Concluded.*

PLOT No	23	25	27	29	Relative yields on Plot 29, reckoning those on Plot 27 as 1.	
FERTILIZERS APPLIED.						
Dissolved Boneblack........Lbs. per acre....	600	600	600	600		
Muriate of Potash........ " "	180	180	180	180		
Sulphate of Ammonia........ " "	360	360	....	....		
Nitrate of Soda........ " "	....	....	465	465		
Air-slacked Lime, during two years... " "	....	6400	....	6400		
NAMES OF CROPS.*	Lbs. per row.	Lbs. per row.	Lbs. per row.	Lbs. per row.	1894	1893
42. Sweet Corn........	0.0	62.1	48.3	53.5	1.11	2.07
43. Oat—(air-dried)........	0.7	4.6	3.2	3.5	1.09	1.26
44. Dandelion........	0.0	16.8	16.6	17.9	1.08	.....
45. Soja Bean........	4.8	62.0	44.0	46.5	1.06	0.75
46. Potato—Early Rose—(tubers)........	1.3	8.3	9.3	9.8	1.05	1.03
47. Spring Rye—(air-dried)........	1.5	3.9	3.9	4.0	1.03	1.13
48. Cowpea........	10.4	83.0	38.5	36.0	0.94	0.80
49. German Millet—(air-dried)........	0.6	5.3	7.0	6.3	0.90	0.87
50. { White Podded Adzuki Bean—(variety of soja bean)	4.3	6.0	6.8	6.0	0.88	0.82
50. { White Podded Adzuki Bean—(beans)........	2.0	3.5	3.5	3.0	.....	.....
51. { Common White Bean........	1.0	6.5	6.8	6.0	0.88	09.4
51. { Common White Bean—(beans and pods)........	0.4	3.9	4.0	3.8	.....	.....
52. Radish—French Breakfast........	0.4	1.6	3.8	3.3	0.87	.....
53. Millet—Golden—(air-dried)........	0.5	8.8	9.6	8.4	0.87	1.04
54. Carrot—Improved Long Orange........	0.0	9.8	12.1	9.0	0.74	.....
55. Carrot—Danvers—(Victoria in 1893)........	0.6	24.0	27.1	19.4	0.71	1.78
56. Watermelon—(fruit)........	85.5	141.7	249.6	160.4	0.64	.....
57. { Corn—Rhode Island Capped—(ears and stover)........	0.0	27.0	28.3	17.3	0.61	0.71
57. { Corn—Rhode Island Capped—(ears)........	0.0	9.3	10.4	5.7	.....	.....
57. { Corn—Rhode Island Capped—(stover)........	0.0	17.7	17.9	11.6	.....	.....
58. Pumpkin—(fruit)........	0.0	31.5	87.2	48.5	0.55	.....
59. Sorrel........	34.5	7.0	76.0	27.5	0.36	.....
60. Lupine—Blue—(air-dried)........	2.9	2.9	6.0	1.4	0.23	0.47

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* The figures represent, in the case of the root crops, the weights of the roots only, and in all other cases the whole plant above ground, unless otherwise stated.

TABLE II.

	PLOT No.	23		25		27		29	
	FERTILIZERS APPLIED.								
	Dissolved Boneblack	600 lbs. per acre.		600 lbs. per acre.		600 lbs. per acre.		600 lbs. per acre.	
	Muriate of Potash	180 " "		180 " "		180 " "		180 " "	
	Sulphate of Ammonia	360 " "		360 " "		.... " "		.... " "	
	Nitrate of Soda	.... " "		.... " "		465 " "		465 " "	
	Air-slacked Lime, during two years	.... " "		6400 " "		.... " "		6400 " "	
	DATES OF HARVESTING THE VEGETABLES.	Per cent. harvested *up to* the respective dates.	Av'ge weights of vegetables harvested *on* respective dates—(lbs).	Per cent. harvested *up to* the respective dates.	Av'ge weights of vegetables harvested *on* respective dates—(lbs).	Per cent. harvested *up to* the respective dates.	Av'ge weights of vegetables harvested *on* respective dates—(lbs).	Per cent. harvested *up to* the respective dates.	Av'ge weights of vegetables harvested *on* respective dates—(lbs).
CUCUMBERS.	July 24	0.0	0.0	2.3	1.1	0.7	0.8	0.7	0.7
	July 30	0.0	0.0	12.4	2.5	6.1	1.5	6.1	2.5
	August 1	0.0	0.0	16.5	0.6	9.3	0.9	7.5	0.7
	August 6	0.0	0.0	31.2	1.3	16.5	1.2	14.1	1.6
	August 8	0.0	0.0	36.1	0.7	20.5	0.4	16.4	0.5
	August 11	0.0	0.0	45.0	1.2	25.7	0.7	21.3	1.1
	August 16	0.0	0.0	61.6	1.5	35.4	2.1	31.7	3.3
	August 20	0.0	0.0	69.4	1.0	49.0	0.6	45.4	1.0
	August 25	0.0	0.0	79.7	1.1	73.2	0.8	64.0	1.1
	August 29	29.4	0.6	82.5	0.7	78.4	0.6	70.6	0.7
	September 1	0.0	0.0	89.2	0.8	84.1	0.7	80.2	0.6
	September 4	64.7	0.7	94.5	0.7	90.3	0.7	88.6	0.6
	September 19	100.0	0.7	100.0	2.8	100.0	3.3	99.3	4.5
	October 11	0.0	0.0	0.0	0.0	0.0	0.0	100.0	2.5
KOHL-RABI.	July 24	0.0	0.0	15.0	4.0	0.0	0.0	28.1	4.7
	July 30	0.0	0.0	62.5	3.6	12.6	2.8	93.7	4.9
	August 6	0.0	0.0	80.0	4.3	20.2	4.3	0.0	0.0
	August 14	10.0	4.0	85.0	4.0	25.3	4.5	96.8	3.0
	August 16	0.0	0.0	87.5	3.0	33.1	3.6	0.0	0.0
	August 27	0.0	0.0	0.0	0.0	43.4	2.8	0.0	0.0
	August 29	0.0	0.0	97.5	3.3	53.7	3.3	0.0	0.0
	September 7	0.0	0.0	97.5	0.0	63.8	3.0	0.0	0.0
	September 24	0.0	0.0	100.0	0.4	74.1	3.5	0.0	0.0
	September 29	100.0	4.0	0.0	0.0	100.0	0.7	100.0	2.0

The results of the 1894 experiment show that plants Nos. 1 to 47 inclusive were benefited by lime, and Nos. 48 to 60 inclusive not only show no benefit from it, but on the other hand, in some instances, positive injury. Here is an instance of the most striking difference in the character of various plants, for, leaving spinach for the present out of consideration, we have at one extreme, plants the yields of which have been increased about eleven times by the application of lime, and at the other a plant which has produced only about one-fourth as much yield as without lime. With one or two exceptions the results obtained with such crops as were grown in 1893 stand practically in accord with those of 1894. One of these exceptions is the soja bean, which in 1893 showed an injury from the use of lime, and the other is the yellow carrot, which in 1893 showed a larger yield with the lime than without it. Certain peculiarities in relation to the lettuce and spinach grown in the two years also deserve attention, namely: in 1893 lettuce showed a greater benefit from the use of lime than spinach, while in 1894 the reverse was true. These variations in the results with spinach and lettuce appear to be due to the fact that immediately after germination they are more susceptible to the injurious action of the acid soil than are the young plants of other kinds. If they succeed in withstanding the conditions long enough to get somewhat of a root system established, their existence is assured even though they make but a limited growth. On this account, if all of the temporary conditions are such at the outstart that the plants can establish themselves on the acid soil, the final results from the use of lime show much less benefit than would have been the case had the existing conditions entirely prevented their establishment. Spinach sown in September has met with equal difficulty in gaining a foothold, thus showing that the unfavorable conditions existing in the surface soil are maintained throughout the season.

Among those plants which showed a decided benefit from the use of lime, a large number are commonly grown in New England, and the remainder are, as a rule, grown to some extent by market gardeners. The Indian corn (field variety) and pumpkin were the only crops grown to any extent in this State which showed any decided injury from the use of lime. While slight injury appears to have resulted in case of millet, it was not enough to be taken into practical consideration. In several experiments with corn on other portions of the Station farm where *small quantities* of lime were used a slight benefit was observable. In pot experiments and in field experiments at Hope Valley, R. I., where lime at the rate of two and one-half tons per acre was used, little or no benefit was apparent. In fact it seems probable that the injurious effect of lime as observed in Table I was due to the fact that so large an application was made. Had a smaller quantity of lime been used the injurious effects upon the Indian corn would doubtless have been less, but the beneficial action upon the majority of the crops grown would have been proportionately decreased. The amount of lime to be used would doubtless depend upon the nature of the plant to be grown as well as upon the degree of acidity of the soil. It is to be hoped for this reason that some satisfactory method for determining the relative acidity of soils may be devised. The ill effect of the lime observed in the case of the pumpkin appears to have been due to the fact that the vines upon the limed plots blighted more than upon the others. Whether the blight was due to the effect of the lime upon the composition of the vine by which it favored the disease, or to the fact that lime may have been spattered upon the leaves during rain-storms—thus rendering them more subject to the disease—it is impossible to conclude. The plants showing the most serious injury from the use of lime are lupines and sorrel. The former is practically not grown in the State, and the latter is one of the worst pests with which the farmer has to contend. The statement is made by agricultural writers that lime is an enemy to sorrel, while on the other hand it is on record that sorrel has been observed to flourish on old mortar beds. Our experiment has shown that sorrel may flourish even where lime is used; this was especially true where it was used in connection with nitrate of soda, and the fact that it succeeded less well where sulphate of ammonia and lime were used indicates that possibly the soda benefits the sorrel. It was highly interesting to observe that where sulphate of ammonia was used without lime the sorrel grew better than upon any other plot in spite of the fact that the soil was in such a condition as to destroy many of our agricultural plants. Considering that the sorrel is decidedly injured by the lime, and that beets, onions, muskmelon, cabbage, cauliflower, cucumber, tobacco, wheat, barley, clover, peas, and many other plants are greatly benefited by its use on our acid soil, it will be seen that the advantages derived from liming, except on fields intended for potatoes,[1] more than counterbalance the disadvantages.

In 1893 several plants which gave the best results upon the sulphate of ammonia and lime plot have in 1894 succeeded better upon the nitrate of soda and lime plot. The results for 1894, with few exceptions, indicate no advantage of the sulphate of ammonia over the nitrate of soda when used in connection with lime. It is impossible to conclude whether this is due to the fact that the soil of the nitrate of soda and lime plot (29) is less acid than the sulphate of ammonia and lime plot (25) or to some beneficial action of the soda. That there should be a decided difference in the acidity of the above-mentioned plots is to be expected, for if we consider that the entire amount of nitrogen applied to each, whether as ammonia or nitric acid, is removed by the plant, it will be seen that the residue is, in the case of plot 25, an acid (sulphuric acid), and, in that of 29, a base (soda). Another group of plants, however, gives more positive evidence of having been benefited to some extent by the soda, a conclusion to which we are led by the fact that some members of the group are but slightly injured by the acidity of the soil, while others have made the best growth where the soil was still quite acid; prominent among the plants of this group are watermelon, radish, flat turnip, rye, potato, rutabaga and tomato. Storer[1] states that the application of soda as a *direct* manure is unnecessary; he further adds that its beneficial action is due to the setting free of other elements within the soil. According to him it "displaces lime first of all, then magnesia, and potash (as well as some phosphoric acid) only to a subordinate extent." That the beneficial action of soda in our experiment could have been due to the setting free of lime seems unreasonable in view of the previous applications amounting in all to over three tons of air-slacked lime per acre, and to the fact that many of the above-mentioned plants were apparently injured by the lime. In view of the large application of soluble phosphoric acid and potash, it appears doubtful if any additional amount of these constituents, which may have been set free by the soda, would have shown such marked effects. The only element, therefore, which might have been made available to the plant by the indirect action of the soda must have been magnesia. Whether the beneficial results observed may have been due to the setting free of this constituent rather than to the direct action of the soda or to its effect upon the physical condition of the soil, the present data render it impossible to determine. It is our intention to apply magnesia to these plots the coming season with the hope that additional light may be thrown upon the question of the direct manurial action of the soda.

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[1] On the effect of lime in increasing the potato scab see Bulletins 26 and 30 of the Rhode Island Agricultural Experiment Station.

An extensive experiment was begun in 1894, a plan of which will be found in a succeeding article, the object of which is to further test the question already touched upon by P. Wagner[2] and Dorsch and Atterberg[3] in regard to the substitution of soda for, and its value in connection with, potash. Plants which in the present experiment show most strongly the beneficial action of soda, and also such as have grown equally well—if not better—upon sulphate of ammonia and lime, will be employed.

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[1] Agricultural Science, Vol. II, p. 161.

[2] Die Stickstoffdüngung, Berlin, 1892, pp. 227-242.

[3] Deut. landw. Presse, 1891, p. 1035. Abs. E. S. R., Vol. III, p. 554.

SUMMARY OF THE RESULTS OF THE FOREGOING EXPERIMENT FOR 1893 AND 1894.

Our sandy loam soil, where the natural drainage is good, has been found to be decidedly sour or acid,[1] and some plants almost refuse to grow while others flourish upon it. By the use of air-slacked lime, which reduces or overcomes the acidity of the soil, the yields of a number of plants have been increased from four to eleven times; with a number of others the yields have been doubled, while with a few plants they have been *reduced* from one-half to one-fourth of those obtained without lime. The plants ordinarily grown in Rhode Island which have shown an injury from the use of three tons of air-slacked lime per acre are the pumpkin, watermelon and Indian corn (field variety). In other experiments, where smaller quantities of lime were used, Indian corn was slightly benefited or uninjured. The time of ripening of the watermelon was hastened by the use of lime, a fact which in our latitude fully compensated for the reduction in its yield. The greatest drawback to the use of lime which we have encountered is its tendency to increase the potato scab.[2] Where lime is used, Bolley's corrosive sublimate treatment has reduced, but not wholly prevented, the scabbiness the first year, though it seems doubtful if potatoes can be grown successively or in frequent rotation on limed soils without eventually suffering serious injury from the scab even if this treatment is resorted to. Lime has invariably increased the yield of large tubers and frequently the total yield, and for this reason it is to be hoped that if Bolley's corrosive sublimate fails to utterly destroy all of the disease germs on seed tubers, that some fully effectual means may be devised for overcoming the scab and at the same time enable one to derive the benefit from the lime. In regard to the maturity of the crop, that of the kohl-rabi was hastened remarkably by the use of lime, and that of the summer squash to some extent.

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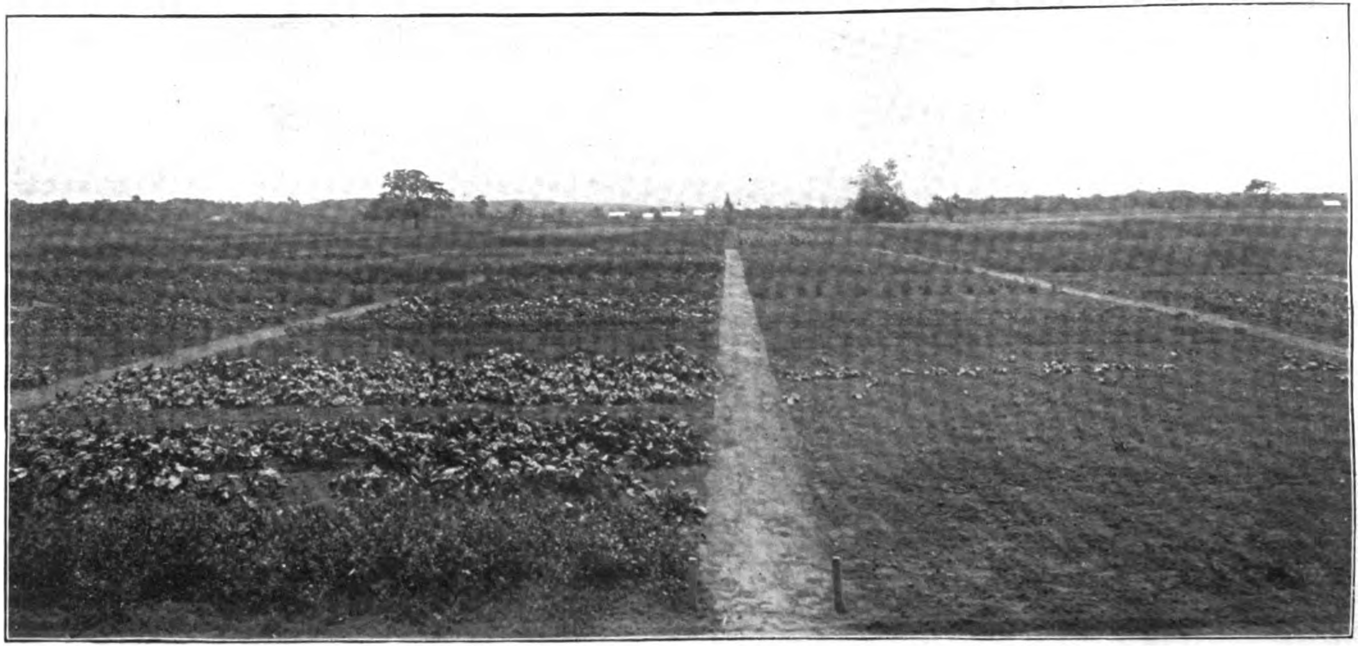
[1] R. I. Agl. Expt. Station, Bulletin 26, p. 142, and Bulletin 28, p. 25.

[2] R. I. Agl. Expt. Station, Bulletin 26, pp. 141-156, and Bulletin 30, pp. 66-85.



Plot 25. Limed. Fig. 1. Plot 23. Unlimed.

Potash, Phosphoric Acid, and *Sulphate of Ammonia*.

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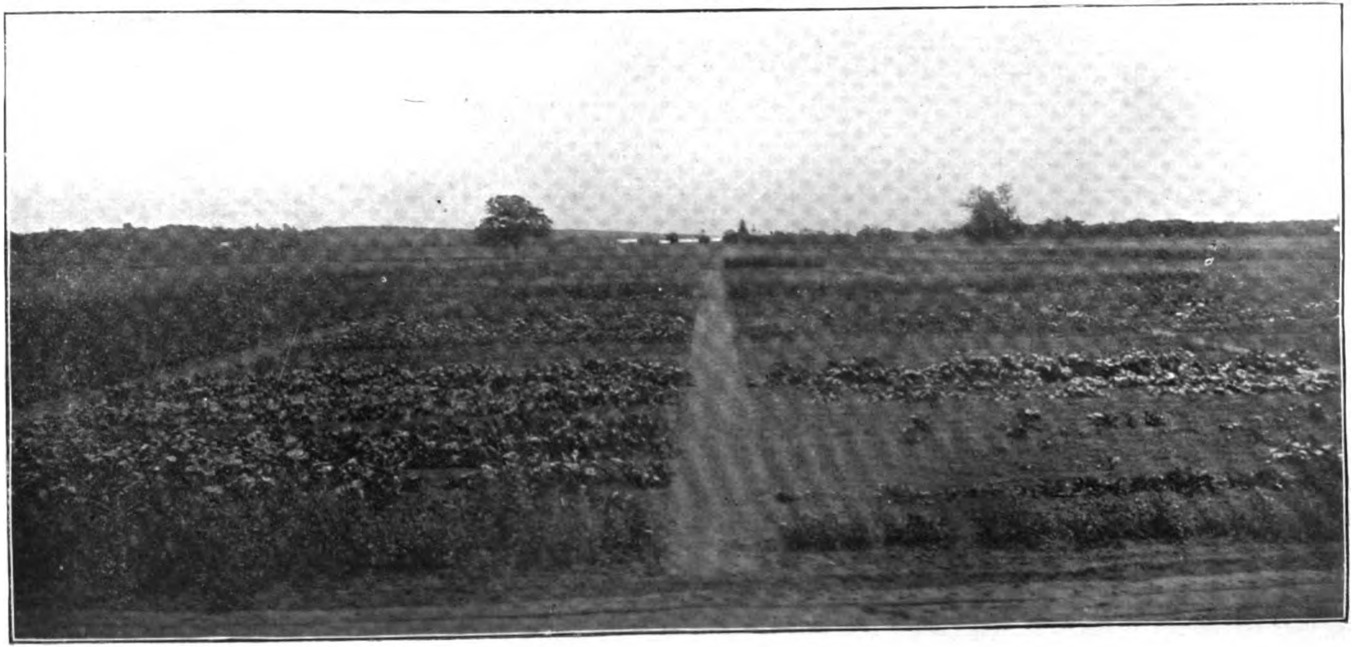

Plot 29. Limed. FIG. 2. Plot 27. Unlimed.

Potash, Phosphoric Acid, and *Nitrate of Soda*.

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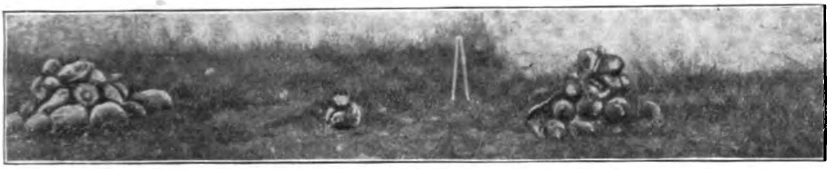

Fig. 3. (No. 3). Sugar Beets.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

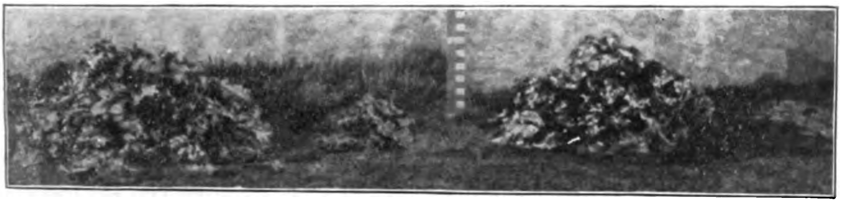

Fig. 4. (No. 6). Celery.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

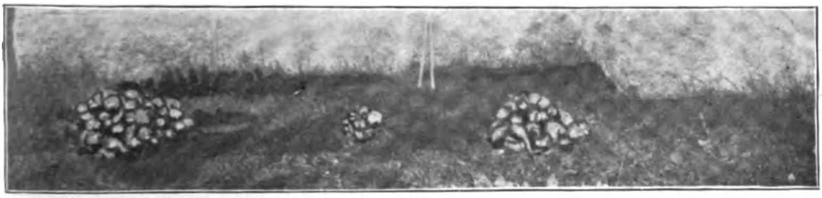

Fig. 5. (No. 9). Yellow Onions.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

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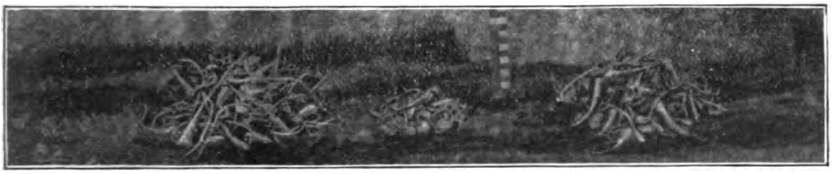

FIG. 6. (No. 10). Parsnip.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

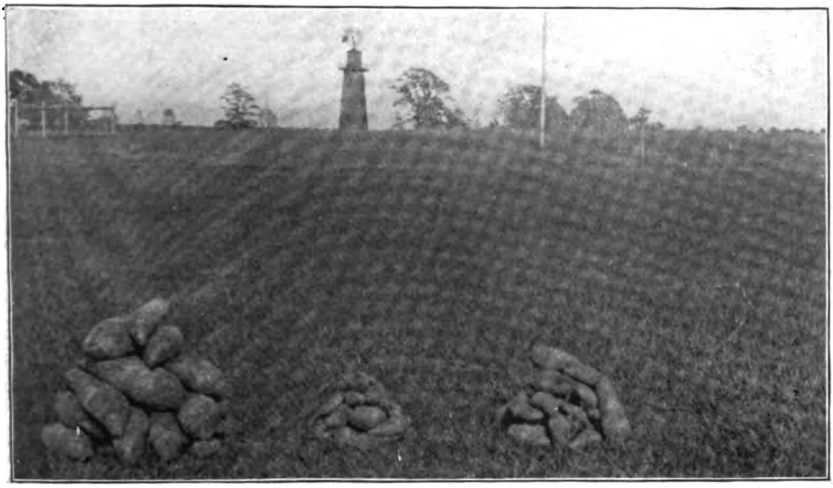

FIG. 7. (No. 11). Long Mangel Wurzel.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

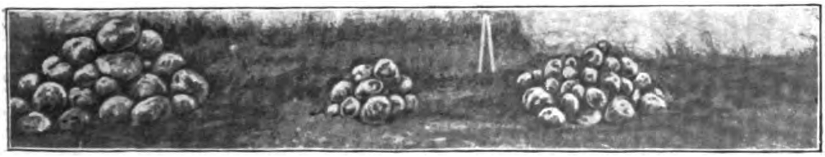

FIG. 8. (No. 12). Table Beets.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

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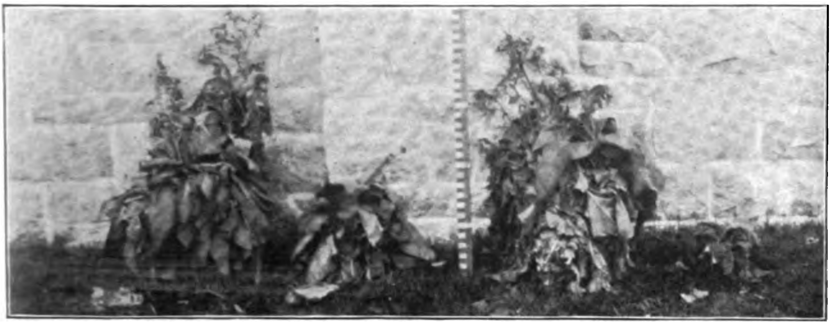

FIG. 9. (No. 15). Tobacco.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

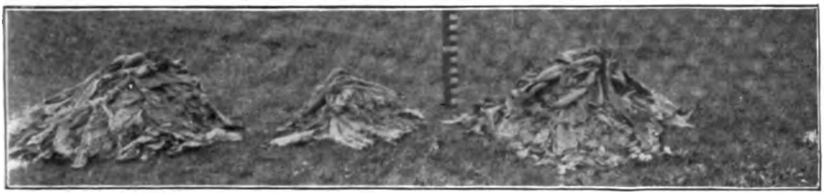

FIG. 10. (No. 17). Cauliflower.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

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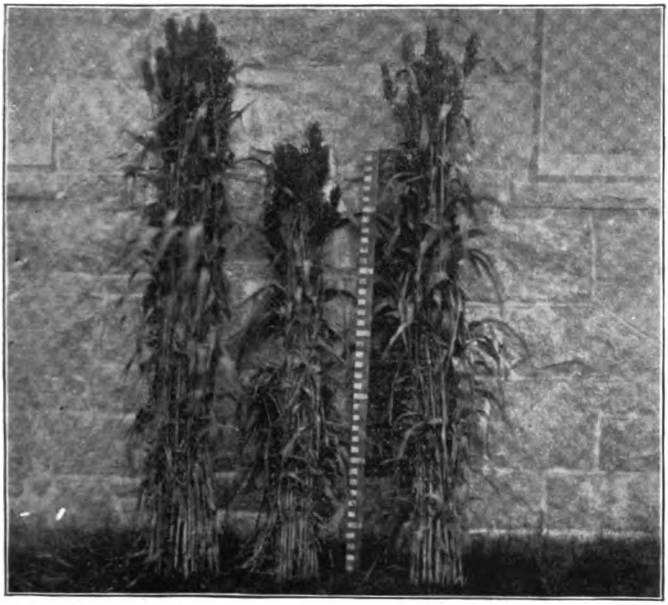

FIG. 11. (No. 19). Sorghum.
Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.
Nitrate of Soda. Sulphate of Ammonia.
All manured alike with Potash and Phosphoric Acid.

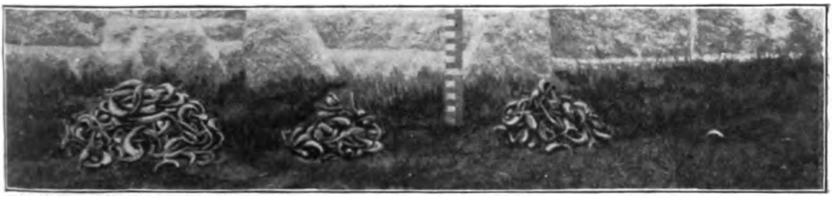

FIG. 12. (No. 20). Martynia Pods.
Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.
Nitrate of Soda. Sulphate of Ammonia.
All manured alike with Potash and Phosphoric Acid.

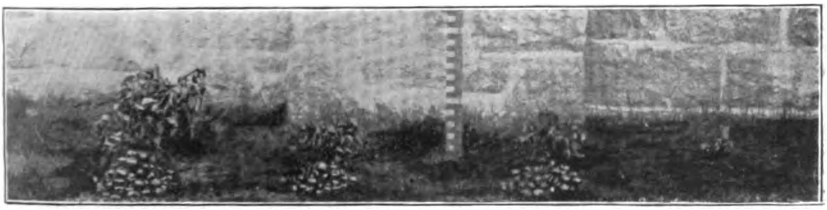

FIG. 13. (No. 21). Peppers.
Plot Nos. 29 Limed. 25. Unlimed. 25. Limed. 23. Unlimed.
Nitrate of Soda. Sulphate of Ammonia.
All manured alike with Potash and Phosphoric Acid.

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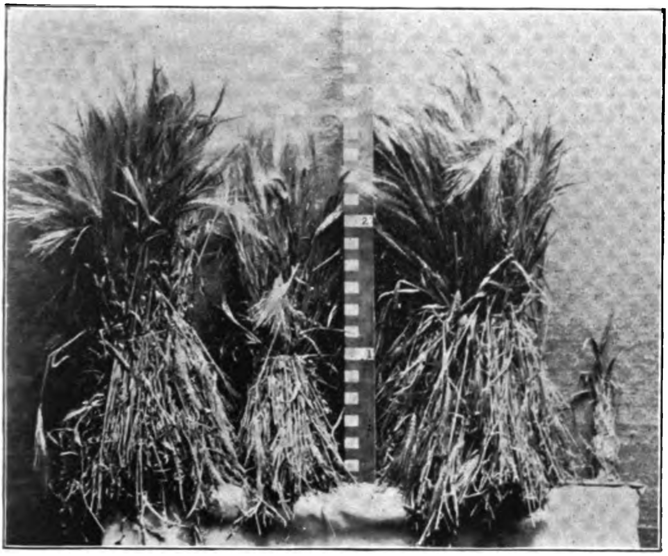

FIG. 14. (No. 23). Barley.
Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.
Nitrate of Soda. Sulphate of Ammonia.
All manured alike with Potash and Phosphoric Acid.

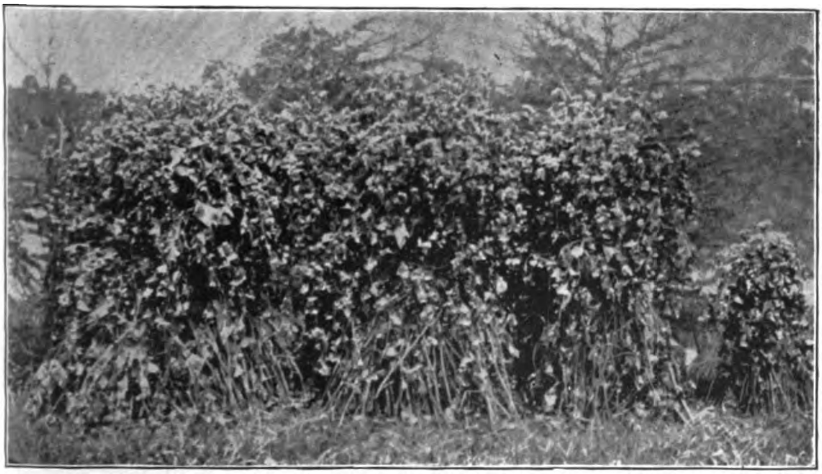

FIG. 15. (No. 31). Buckwheat.
Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.
Nitrate of Soda. Sulphate of Ammonia.
All manured alike with Potash and Phosphoric Acid.

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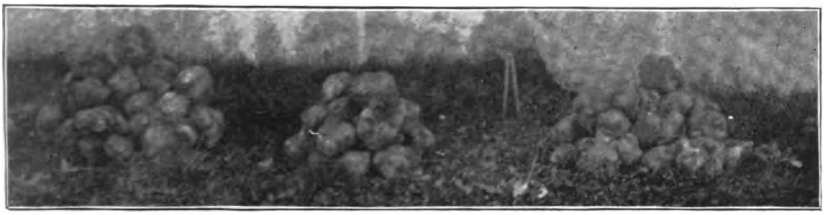

FIG. 16. (No. 32). Rutabagas or Swedish Turnips.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

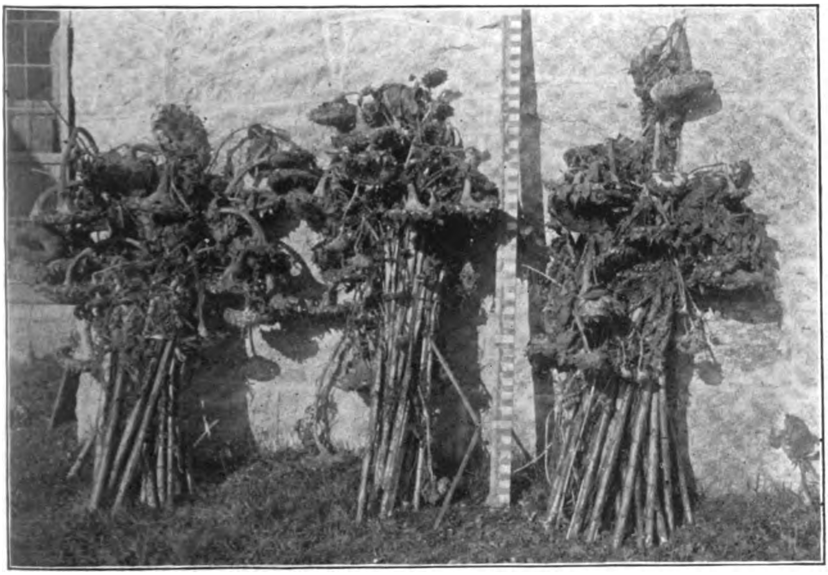

FIG. 17. (No. 34). Sunflower.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

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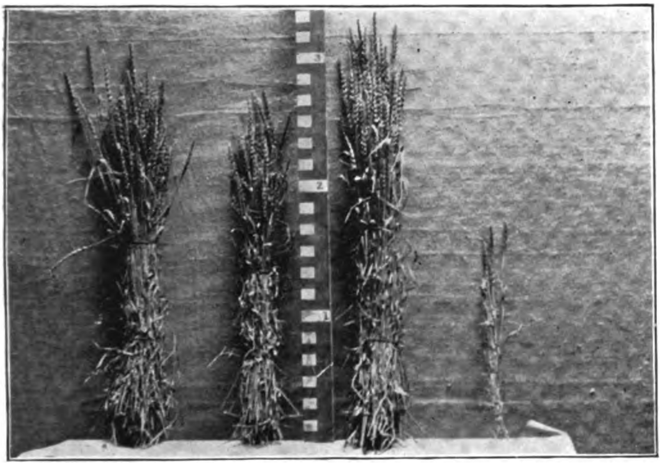

FIG. 18. (No. 35). Spring Wheat.
Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.
Nitrate of Soda. Sulphate of Ammonia.
All manured alike with Potash and Phosphoric Acid.

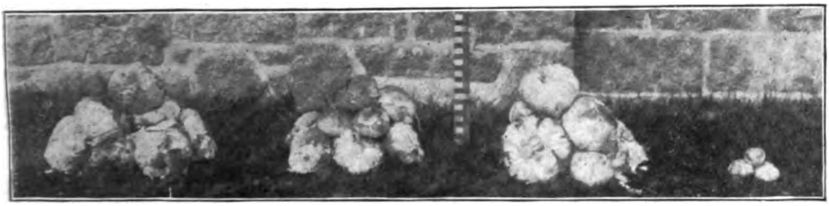

FIG. 19. (No. 38). Early Cabbage.
Plot No. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.
Nitrate of Soda. Sulphate of Ammonia.
All manured alike with Potash and Phosphoric Acid.

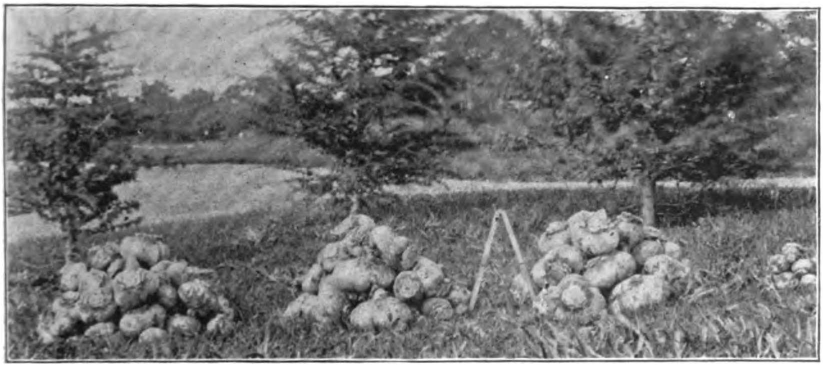

FIG. 20. (No. 40). Early Red Top Turnip (flat).
Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.
Nitrate of Soda. Sulphate of Ammonia.
All manured alike with Potash and Phosphoric Acid.

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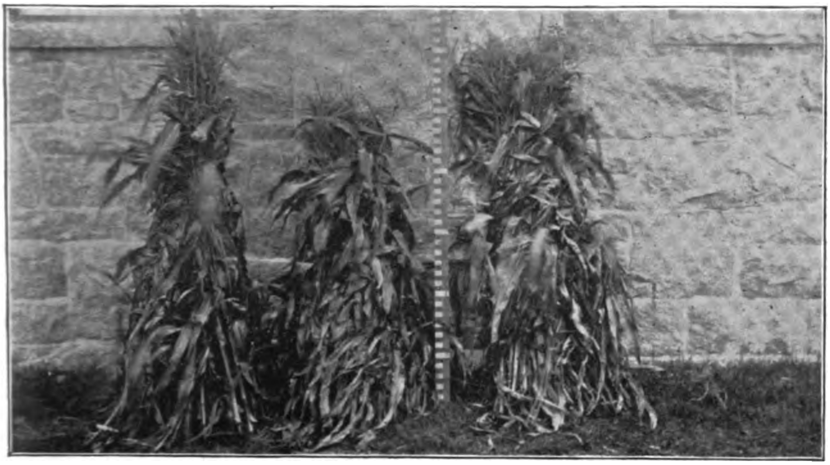

FIG. 21. (No. 42). Sweet Corn (maize).

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

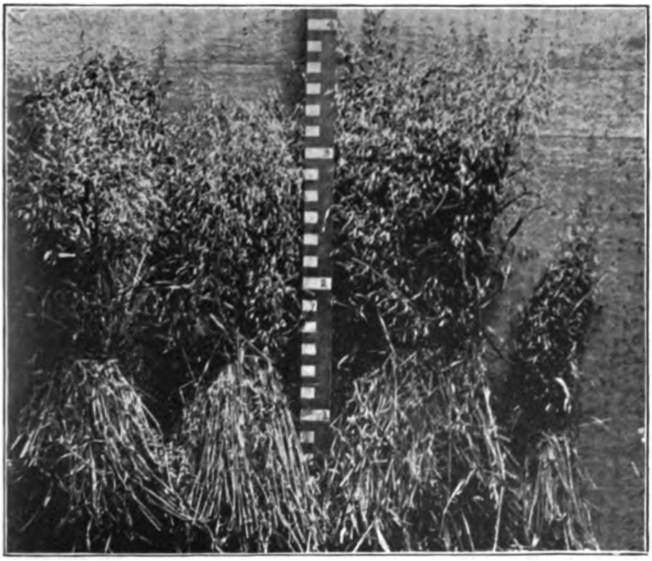

FIG. 22. (No. 43). Oats.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

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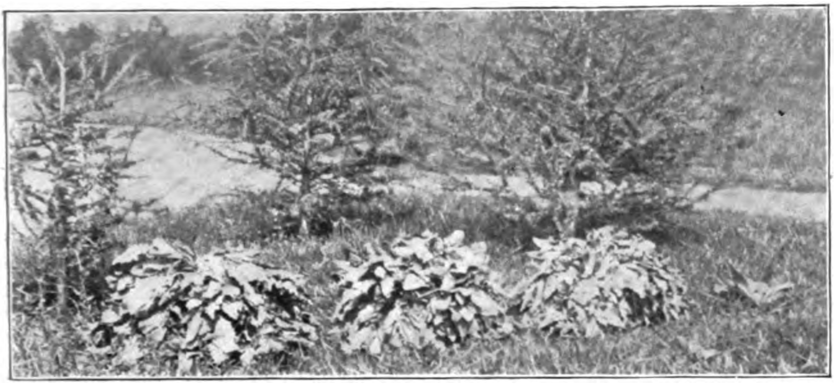

FIG. 23. (No. 44). Dandelion.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

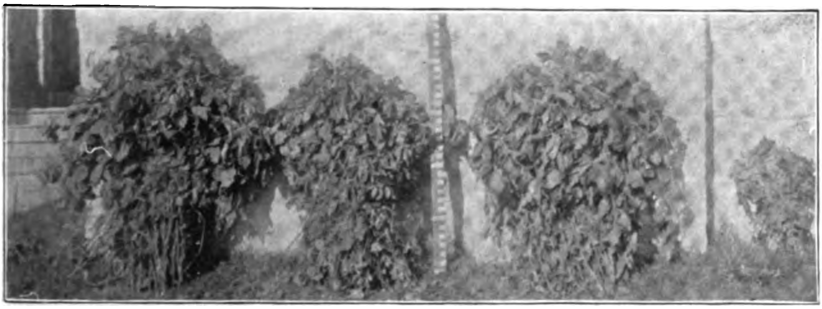

FIG. 24. (No. 45). Soja Bean.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

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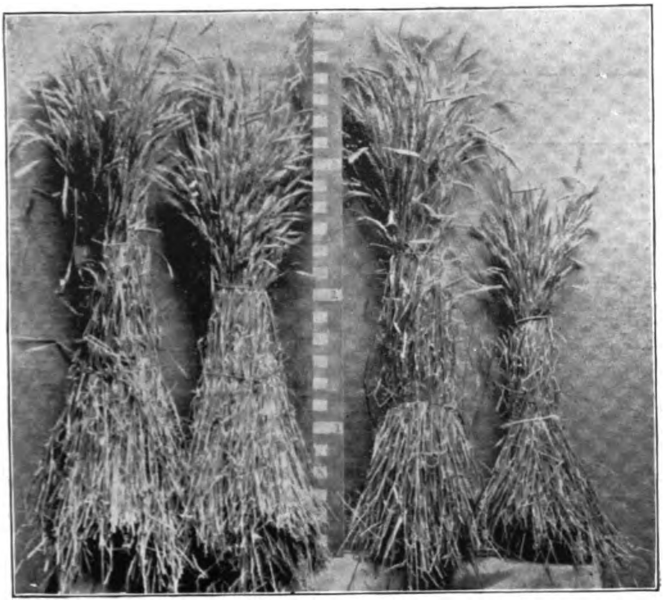

Fig. 25. (No. 47). Spring Rye.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

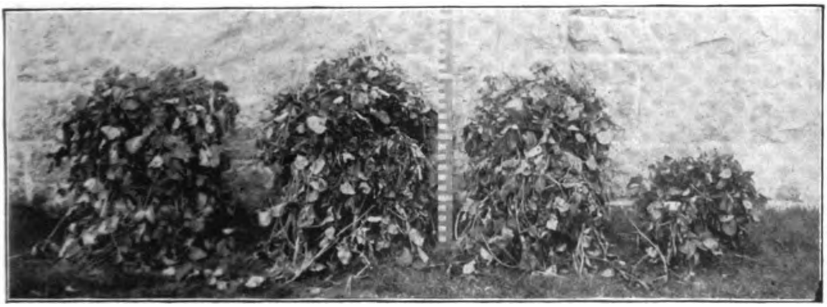

Fig. 26. (No. 48). Cowpea.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

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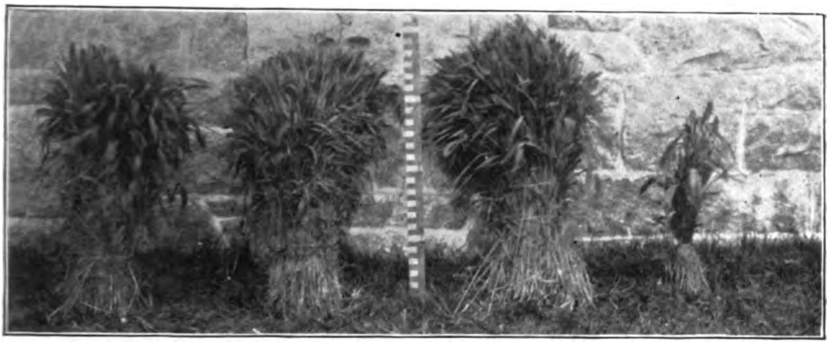

Fig. 27. (No. 49). German Millet.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

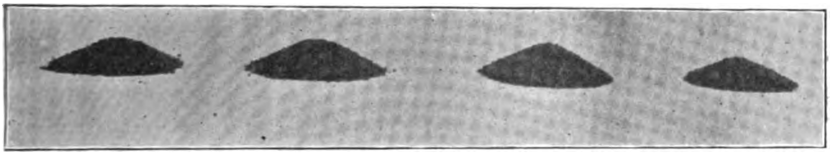

Fig. 28, (No. 50). White Podded Adzuki.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

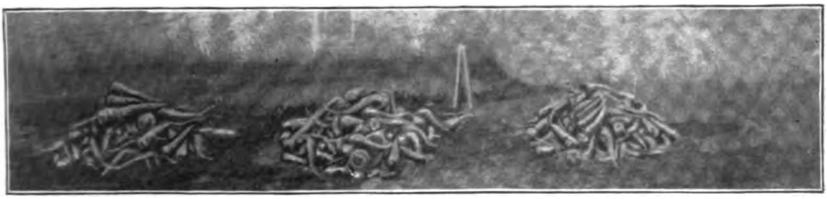

Fig. 29. (No. 55). Yellow Carrot (Danvers).

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

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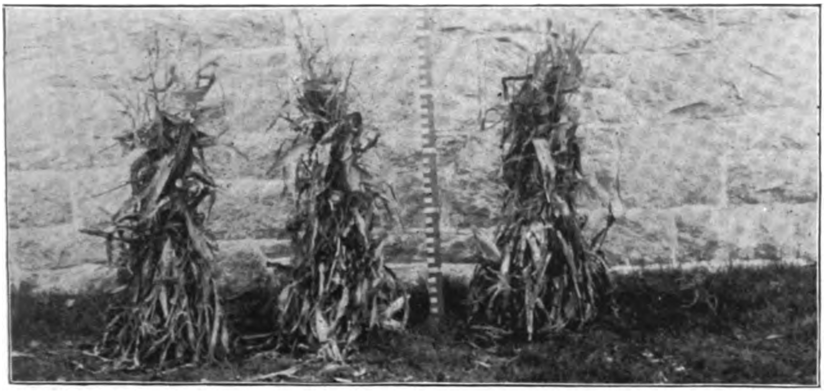

FIG. 30. (No. 57). Field Corn (Maize).

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

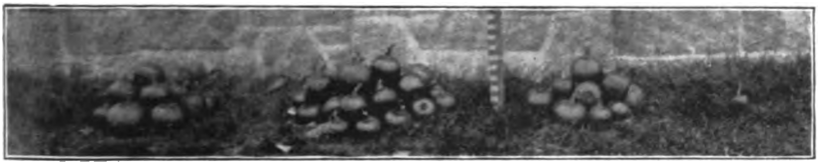

FIG. 31. (No. 58). Pumpkins.

Plot Nos. 29. Limed. 27. Unlimed. 25. Limed. 23. Unlimed.

Nitrate of Soda. Sulphate of Ammonia.

All manured alike with Potash and Phosphoric Acid.

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Spinach and lettuce were more seriously affected by the acidity of the soil than any other crops grown, and almost failed in some instances to gain a foothold even though the seeds germinated well. The most important Rhode Island crops which were decidedly benefited by the use of lime were the beet, onion, muskmelon, cabbage, cauliflower, cucumber, barley, red clover, pea, and rutabaga or Swedish turnip. Tobacco, sorghum and wheat, though not Rhode Island crops, should also be mentioned, owing to the fact that they are important crops elsewhere. A number of crops less generally cultivated were also greatly benefited by lime, as can be seen by Table I on pages 158, 159, 160.

Marked differences have been observed between individual members of the same family of plants; for example, of two leguminous plants, the clover and the lupine, the former cannot be grown successfully on our soil without lime, barnyard manure, or some other alkaline treatment, while the latter is injured by lime; again, in respect to the melon family, the muskmelon was a total failure without lime, while the total yield of watermelons was not increased by it. In regard to the cereals, barley was not a success without lime; wheat and oats were benefited by it in the order named, though in a less degree, while the rye derived but little benefit from it. The results indicate that lime rids soil of sorrel more on account of the fact of its putting the soil in a condition to produce clover and other agricultural plants, which in turn crowd it out, than to the inability of the sorrel to grow on limed land.

Probably the amount of lime which should be used upon sour soils would depend upon the degree of their acidity and the crops to be raised. The results indicate that possibly certain plants *may* be benefited directly by soda, and others not.

Perhaps the most important points brought out by this experiment are the following, namely, the necessity for the examination of upland soils relative to their acidity, and the recognition of its possible effect in connection with plant experiments, and also the necessity of employing a large number of plants in experiments by which it is hoped to establish general principles.

ON THE SUBSTITUTION OF SODA FOR, AND ITS VALUE IN CONNECTION WITH, POTASH.

H. J. WHEELER, J. D. TOWAR, AND G. M. TUCKER.

Innumerable observations on the manurial effect of common salt (sodium chloride) are on record, and many favorable and unfavorable results from its use have been obtained; in fact, most writers on agricultural chemistry claim at the present time that, even though it may be essential to the plant, its application to the soil is unnecessary for the reason that sufficient is already present in all soils, and that more or less salt is constantly being supplied to them by the rain which carries it down from the atmosphere. In actual practice, applications of salt have often proved decidedly beneficial, yet this has been almost universally attributed to the action of the soda in setting potash free from comparatively insoluble potash compounds already existing in the soil. In this respect the action of salt is like that of gypsum or land plaster, though according to Storer[1] it is less efficacious in this respect than the latter. In consequence of this function of salt, Deherain[2] states that its application on calcareous soils is superfluous. Johnston,[3] an early English authority, and more recently Griffiths,[4] assert that soils may sometimes be so deficient in salt that, in connection with certain crops, it is decidedly beneficial as a direct manure. The particular plant mentioned by Griffiths as being especially benefited by soda is the mangel-wurzel. In a tabulated summary of experiments with mangel-wurzels and sugar beets Stützer[1] has shown that applications of nitrate of soda have produced in general much larger yields than the same quantities of nitrogen in form of sulphate of ammonia. The advantage from the nitrate of soda was far greater with these crops than with others with which experiments have been conducted. We have not, up to the time of writing, had opportunity to look up the details of all these experiments, and cannot for this reason say whether or not abundant applications of potash were also made. In all probability, however, such was the case in many instances, and that this effect was due to some other cause than the liberation of potash seems probable. The results of our own experiments in 1893 and 1894, not only with beets of various kinds, but also with spinach, lettuce, and even other plants, showed much greater yields in connection with nitrate of soda than with the same amount of nitrogen in the form of sulphate of ammonia, even when air-slacked lime at the rate of two and one-half and three tons per acre was used with both. In the course of our experiments it was observed that the plants enumerated above were seriously affected by the acidity of the soil, and it appeared possible that the amount of lime applied might not have been enough to have entirely overcome the acidity more particularly in the case of the sulphate of ammonia plots. That such differences in the acidity of the two plots may have existed seems probable owing to the acid tendency of the sulphate of ammonia and the alkaline tendency of the nitrate of soda. *In how far the difference in yields of the beets, spinach and lettuce is attributable to the variation in the acidity of the two plots on the one hand, and to a direct manurial action of the soda on the other, it is impossible to conclude.* It is possible that such differences may have existed in the acidity of the soils upon which the experiments tabulated by Stützer were conducted, though in many cases this is perhaps improbable, owing to the possibility that many of the experiments may have been conducted upon limestone soils, where the existence of any considerable degree of soil acidity would not be expected; we find, however, no mention of the acidity of the soil as a possible cause of such differences, either by Stützer or other experimenters engaged in practical field trials of the two compounds.

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[1] Agriculture, Vol. II, p. 161, New York, 1889.

[2] Traité de Chimie Agricole, p. 789, Paris, 1892.

[3] Agricultural Chemistry, p. 346, New York.

[4] A Treatise on Manures, p. 252, London, 1889.

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[1] Chilisalpeter, p. 98.

The most important data bearing upon the direct manurial value of soda are those furnished by P. Wagner and Dorsch[1] and Atterberg.[2] Wagner and Dorsch conclude from the results of three years' experiments with barley and carrots that "the soda is able to exert a decided influence upon the development of plants and that cultivated plants are able to produce almost half as much more yield out of one and the same amount of potash when they are manured with sodium chloride." They do not claim that soda can be substituted for and perform all the functions of potash, but that the employment of soda enables the plant to utilize to better advantage the potash which is at its disposal. In further substantiation of the idea that soda is of direct manurial value to plants, the above-mentioned writers call attention to experiments by Mærcker and Samek,[3] also to a summary by Warington[4] of the experiments at Rothamstead, and those of Bæssler,[5] in which, especially in connection with certain plants, given quantities of nitrogen in the form of sulphate of ammonia proved decidedly inferior to the same quantities in the form of nitrate of soda. Wagner and Dorsch attempt to explain these differences on the ground that the soils in question were deficient in soda and perhaps to some extent in potash, and that the soda of the nitrate of soda enabled the plants to make a better use of the limited potash supply.

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[1] Die Stickstoffdüngung, pp. 227-242.

[2] Deut. landw. Presse, 1891, p. 1035. Abs. E. S. R., Vol. III, p. 554.

[3] Tyroler landw. Blätter, 7 Jahrg 1889, No. 2, pp. 14, 15. Abs. in Biedermann's Central-blatt, 1889.

[4] Reprint from Gas Engineer's Annual, 1889. Abs. in Biedermann's Central-blatt, 1889, p. 448.

[5] Wochenschrift der pommerschen ökonomischen Gesellschaft, Jahrg. 1888. Also, Abs. Biedermann's Central-blatt, 1889, pp. 14-18.

In our experiments we have found that sulphate of ammonia has proved in most instances inferior to nitrate of soda and in some injurious to plants, a result which in our case was in all probability largely attributable to the acidity of the soil and its effect upon the nitrification of the sulphate of ammonia, which factor appears not to have been taken into consideration in the least by Wagner and Dorsch and by the other experimenters whose results they cite in support of the manurial value of soda. We would not attempt to explain all the differences cited by Wagner and Dorsch upon the ground of probable acidity of the soil, for in some cases it is possible that soda as well as soil acidity may have played an important part; yet in view of our own experience we are forced to the opinion that the above-mentioned writers may have gone too far in their conclusions. Atterberg's experiments were conducted in pots in which quartz sand served as soil, and this material being devoid of lime, magnesia, phosphoric acid and potash, furnished excellent conditions for judging of the direct manurial effect of soda, for, in the absence of the above ingredients, no indirect action of the soda in setting them free could have been possible. The pots were watered with nutritive solutions containing acid potassium phosphate, magnesium sulphate and potassium, sodium and calcium nitrates. Different amounts of the potassium were replaced by like amounts of sodium in the first series and of calcium in the second series. Where soda was substituted for part of the potash the yields were decreased to a less extent than where calcium was similarly substituted, from which Atterberg concludes "that sodium may fill a very important function in case of a deficiency in potassium, and it is therefore not to be regarded as an altogether useless plant constituent."

Pagnoul,[1] also, in experiments with clover in successive years, found that the use of potash in connection with sulphate of ammonia raised the yield to a much greater extent than when used in connection with nitrate of soda. The conditions under which these experiments were conducted indicate that the results were probably due to some direct fertilizing function of the soda.

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[1] Annales Agronomiques, 17, 1891, pp. 538-544.

From the foregoing experiments it may be seen that soda may, in the lack of an abundant supply of potash, be of some direct benefit to *certain* plants; but when we consider that spinach, lettuce, beets and other plants contain large quantities of soda and still others very small quantities, it would appear altogether too hasty to draw a conclusion therefrom as to the needs of plants in general. A further point which should be considered in connection with these experiments is that *the soil with which Atterberg and Pagnoul, at least, worked, was artificial or abnormal and in no sense what would be called agricultural soil, and even though soda was found under such circumstances to be beneficial to the plants under experiment, the observations furnish no evidence that the amount of soda in ordinary cultivated soils is ever so little that its artificial application would enable the plant to make a better use of the potash naturally existing in the soil or of that which is applied artificially.*

Our own experiments were conducted in pots and in the field. The field experiment was conducted upon the portion of the Station farm known as the "plain"; the soil consists of sandy loam immediately underlaid by yellow loam subsoil and then by alternating layers of sand and gravel which afford good natural drainage. Previous experiments have shown the soil to be, for most crops, lacking in assimilable phosphoric acid to a greater degree than in potash, though practically sufficient potash is present for the profitable production of one or two crops, after which its application becomes decidedly necessary. The following is a chemical analysis of the soil according to the Hilgard and Grandeau methods:

	Per cent.
Coarse materials (greater than .5 mm)	12.56
Fine earth	87.44
	100.00

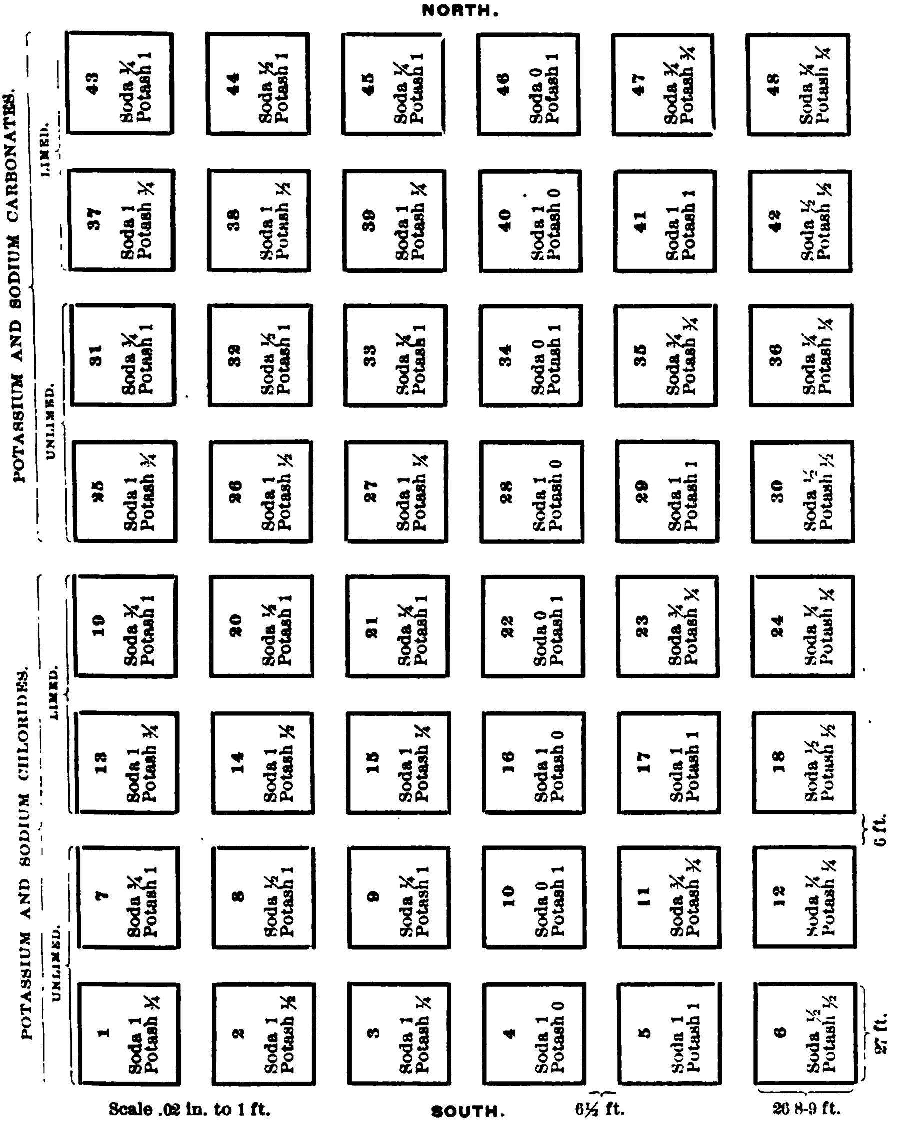
ANALYSIS OF FINE EARTH.

	Per cent.
Insoluble matter	80.632
Soluble silica (SiO_2)	2.032
Potash (K_2O)	.155
Soda (Na_2O)	.108
Lime (CaO)	.569
Magnesia (MgO)	.209
Brown oxide of manganese (Mn_3O_4)	*trace.*
Peroxide of iron (Fe_2O_3)	3.463
Alumina (Al_2O_3)	4 641
Phosphoric acid (P_2O_5)	.127
Sulphuric acid (SO_3)	.125
Water and organic matter	7.888
Total	99.949

The soil is acid to such an extent that injurious results from the application of sulphate of ammonia have been observed for several consecutive years. In a special experiment for the purpose it has been ascertained that while some plants flourish better upon this soil in its acid condition than after liming, others practically refuse to grow until the acidity of the soil has been decidedly reduced or overcome by lime, wood-ashes, barnyard manure, or other alkaline treatment. This latter observation showed the necessity for special precautions in the planning of this experiment, for the reason that beets and certain other plants, which it seemed desirable to employ, would, without some alkaline treatment, be unable to make a satisfactory growth, and thus fail to furnish any reliable data as to the influence of soda. For this reason carbonates of potash and soda were employed in the case of one group of plots with the expectation that their alkaline action would enable the above-mentioned crops to succeed where by the use of chlorides of potassium and sodium they probably would not. In order that satisfactory comparisons might be drawn, it became necessary to determine the alkalinity of both the sodium and potassium carbonates and to employ an amount of the one which would neutralize the same amount of acid as the amount of the other which was employed; for example, the full ration of soda and three-quarters ration of potash were capable of reducing the acidity of the soil in the same degree as a full ration of potash and three-quarters ration of soda. Had like weights of carbonates of potash and soda been substituted for each other the soil would have been made more alkaline by the soda than by the potash, a factor which, though having nothing to do with the direct manurial value of the soda or its action in setting other elements free, would have led to a false interpretation of the results secured and also to the belief that the soda had been of direct manurial benefit when it had not, for only when the same degree of acidity is preserved in each of the plots under comparison can reliable conclusions be drawn. It will be seen, therefore, that the difficulties attending such an investigation are much greater than is generally supposed, and that conclusions from results in which this factor was left out of consideration must, as in the case of those drawn by P. Wagner and Dorsch from Bæssler's experiment with potatoes, be in a great measure misleading.

The land used for this experiment had been in grass prior to 1893, when Indian corn was grown without manure, for the purpose of further exhausting the soil and of ascertaining if it was sufficiently uniform for experimental purposes. The uniformity of the soil was perhaps as great as could be expected, considering the area involved. As it is designed to continue the experiment a number of years, any slight lack of uniformity which pre-existed must eventually lose its significance, and those differences resulting from the fertilizers used upon the individual plots become more prominent. The plan of the field and its subdivision into plots, together with the various combinations of potash and soda, both with and without lime, is given on the opposite page. A second plan shows the direction and arrangement of the rows and the plants employed in the experiment of 1894.

PLAN SHOWING THE ARRANGEMENT OF THE PLOTS AND THE KINDS OF FERTILIZING MATERIAL* APPLIED TO EACH.

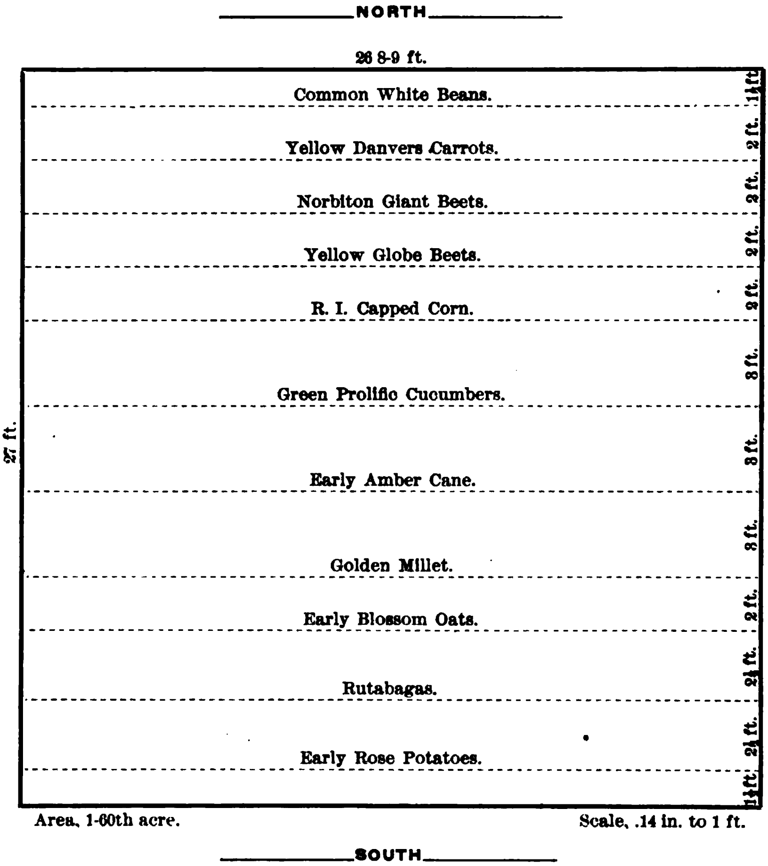


43 Soda ¾ Potash 1	44 Soda ½ Potash 1	45 Soda ¼ Potash 1	46 Soda 0 Potash 1	47 Soda ¾ Potash ¾	48 Soda ¼ Potash ¼
37 Soda 1 Potash ¾	38 Soda 1 Potash ½	39 Soda 1 Potash ¼	40 Soda 1 Potash 0	41 Soda 1 Potash 1	42 Soda ½ Potash ½
31 Soda ¾ Potash 1	32 Soda ½ Potash 1	33 Soda ¼ Potash 1	34 Soda 0 Potash 1	35 Soda ¾ Potash ¾	36 Soda ¼ Potash ¼
25 Soda 1 Potash ¾	26 Soda 1 Potash ½	27 Soda 1 Potash ¼	28 Soda 1 Potash 0	29 Soda 1 Potash 1	30 Soda ½ Potash ½
19 Soda ¾ Potash 1	20 Soda ½ Potash 1	21 Soda ¼ Potash 1	22 Soda 0 Potash 1	23 Soda ¾ Potash ¾	24 Soda ¼ Potash ¼
13 Soda 1 Potash ¾	14 Soda 1 Potash ½	15 Soda 1 Potash ¼	16 Soda 1 Potash 0	17 Soda 1 Potash 1	18 Soda ½ Potash ½
7 Soda ¾ Potash 1	8 Soda ½ Potash 1	9 Soda ¼ Potash 1	10 Soda 0 Potash 1	11 Soda ¾ Potash ¾	12 Soda ¼ Potash ¼
1 Soda 1 Potash ¾	2 Soda 1 Potash ½	3 Soda 1 Potash ¼	4 Soda 1 Potash 0	5 Soda 1 Potash 1	6 Soda ½ Potash ½

NOTE.—The figures following the words "Potash" and "Soda" show whether the maximum amount or some fraction thereof was used.

* In addition to the above, each plot (one-sixtieth acre) received—dissolved phosphate rock, 10 lbs.; floats, 5 lbs.; fine ground bone, 8 lbs.; and dried blood, 12 lbs.

PLAN OF ONE OF THE FOREGOING PLOTS, SHOWING THE KIND OF CROPS GROWN AND THE POSITION OF THE ROW OF EACH.



A uniform application of phosphoric acid and nitrogen was made upon the plots by broadcasting, at the following rates per acre: dissolved phosphate rock, 600 lbs.; undissolved phosphate rock (floats), 300 lbs.; fine ground bone, 180 lbs.; and dried blood, 720 lbs. Plots 13 to 24 (inclusive) and 37 to 48 (inclusive) received air-slacked lime, which was applied uniformly at the rate of two tons per acre. Full, three-quarters, one-half, and one-quarter rations (designated in the field plan and following table of yields by 1, ¾, ½ and ¼ respectively,) of potash and soda as carbonates and chlorides were applied broadcast as shown in the succeeding plan and table. A full ration of soda (Na_2O) consisted of 2.28 lbs. per plot, requiring of sodium chloride (common salt) 4.47 lbs., and of sodium carbonate (soda ash) 4 lbs. A full ration of potash (K_2O) consisted of 3.35 lbs. per plot, requiring of potassium chloride (muriate of potash) 6.2 lbs., and of potassium carbonate 5.94 lbs. It will be noticed that the quantities constituting the full rations of potassium and sodium carbonates are not identical—a smaller quantity of sodium carbonate having been applied, as before stated, in order that its alkaline action might be equivalent to that of the potassium carbonate. The chief difficulty in a field experiment of this nature is that it is impossible to obtain potassium chloride and carbonate of desired purity at such a price as to permit of their use on so large a scale. The objection might be raised to this experiment that both the potassium chloride and carbonate contained small quantities of soda, yet this fact does not materially affect the practical bearing of the experiment for the reason that the commercial muriate and sulphate of potash which are used in ordinary commercial fertilizers, and by farmers generally, contain soda in small quantities, and *the question to be answered for the farmer is whether the use of soda in addition to that naturally existing in the soil and the manures which he employs possesses any advantages or not.* It has been our purpose to test the question in a practical way in the field under such conditions as the farmer meets. It is also hoped that this field experiment will furnish some data as to what particular plants are benefited or injured by soda if such differences exist. In this respect the experiment will serve a preliminary purpose and perhaps give indications in relation to the individual peculiarities of plants upon which pot experiments may be based. Owing to the fact that more uniform soil conditions can be secured and chemically pure reagents employed, it is hoped that eventually more exact results may thus be obtained than are possible in the field. The planting was done on June 6th and 7th. A period of excessive drought followed immediately after planting, which delayed the germination of some of the smaller seeds for some time—a circumstance which renders less uniform than otherwise the results with the beets and carrots. The oats came up so unevenly that the results secured with them have been omitted, as have also those with corn, owing to the fact that crows pulled up many of the young plants. The yields obtained from the various plots are given in the following tables:

TABLE SHOWING YIELDS, IN POUNDS, OF VARIOUS PLANTS, WHEN POTASH AND SODA WERE USED SEPARATELY AND COMBINED IN VARIOUS PROPORTIONS.

	SODIUM CHLORIDE AND POTASSIUM CHLORIDE.																							
	UNLIMED.												LIMED.											
	1 ration Soda. ¾ ration Potash.	1 ration Potash. ¾ ration Soda.	1 ration Soda. ½ ration Potash.	1 ration Potash. ½ ration Soda.	1 ration Soda. ¼ ration Potash.	1 ration Potash. ¼ ration Soda.	1 ration Soda. 0 ration Potash.	1 ration Potash. 0 ration Soda.	1 ration Soda. 1 ration Potash.	¾ ration Potash. ¾ ration Soda.	½ ration Soda. ½ ration Potash.	¼ ration Potash. ¼ ration Soda.	1 ration Soda. ¾ ration Potash.	1 ration Potash. ¾ ration Soda.	1 ration Soda. ½ ration Potash.	1 ration Potash. ½ ration Soda.	1 ration Soda. ¼ ration Potash.	1 ration Potash. ¼ ration Soda.	1 ration Soda. 0 ration Potash.	1 ration Potash. 0 ration Soda.	1 ration Soda. 1 ration Potash.	¾ ration Potash. ¾ ration Soda.	½ ration Soda. ½ ration Potash.	¼ ration Potash. ¼ ration Soda.
PLOT No.	1	7	2	8	3	9	4	10	5	11	6	12	13	19	14	20	15	21	16	22	17	23	18	24
White Beans—(whole plant dried)	2.6	3.6	4.8	3.6	4.0	4.5	4.8	3.8	3.0	3.8	4.3	4.3	4.0	2.6	2.0	2.3	1.3	2.5	3.1	2.8	3.8	2.8	4.0	3.5
Carrots—(roots)	4.8	0.8	4.3	0.8	1.6	1.8	1.3	3.5	1.0	0.0	4.0	2.8	14.5	13.5	5.8	3.0	12.3	10.5	3.0	2.5	4.5	8.0	6.0	16.0
Beets—Norbiton Giant—(roots)	0.0	0.1	0.5	0.0	1.0	0.1	0.0	0.1	0.1	0.0	0.3	0.1	23.8	17.0	17.3	24.5	10.1	22.5	4.8	12.8	7.6	21.5	6.3	22.1
Beets—Yellow Globe—(roots)	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	3.5	23.0	19.0	25.3	12.6	25.3	8.8	16.3	6.4	17.0	9.5	12.3
Cucumbers	2.3	2.4	2.6	5.1	2.9	8.7	1.2	8.9	1.3	8.2	0.9	4.1	5.3	13.0	6.2	29.4	2.3	8.5	0.5	11.2	2.5	5.2	4.9	4.6
Sorghum	0.8	0.5	0.5	0.8	0.8	0.8	0.3	1.5	0.3	1.8	2.0	1.9	5.6	14.8	7.0	9.0	4.4	18.3	0.9	9.0	1.3	7.6	4.8	11.4
Millet	15.0	9.3	17.0	12.6	12.3	14.9	17.3	11.8	9.8	11.1	9.3	10.1	18.6	18.8	18.6	13.3	13.4	9.6	8.1	11.0	9.8	7.8	8.1	8.0
Turnips—Rutabaga—(roots)	64.0	41.3	67.8	62.5	47.3	65.5	38.0	40.0	39.0	42.0	32.5	46.0	76.4	85.0	93.1	85.4	68.5	54.3	44.0	53.4	67.5	64.8	79.5	59.3
Potatoes- (tubers)	13.8	10.3	10.8	11.8	11.5	13.0	9.3	11.5	12.0	14.3	15.3	13.9	11.5	14.0	12.5	12.5	9.8	12.6	9.3	12.3	12.8	11.4	11.5	12.0

TABLE SHOWING YIELDS, IN POUNDS, OF VARIOUS PLANTS, WHEN POTASH AND SODA WERE USED SEPARATELY AND COMBINED IN VARIOUS PROPORTIONS.

	SODIUM CARBONATE AND POTASSIUM CARBONATE.																							
	UNLIMED.												LIMED.											
	1 ration Soda. ¾ ration Potash.	1 ration Potash. ¾ ration Soda.	1 ration Soda. ½ ration Potash.	1 ration Potash. ½ ration Soda.	1 ration Soda. ¼ ration Potash.	1 ration Potash. ¼ ration Soda.	1 ration Soda. 0 ration Potash.	1 ration Potash. 0 ration Soda.	1 ration Soda. 1 ration Potash.	¾ ration Potash. ¾ ration Soda.	½ ration Soda. ½ ration Potash.	¼ ration Potash. ¼ ration Soda.	1 ration Soda. ¾ ration Potash.	1 ration Potash. ¾ ration Soda.	1 ration Soda. ½ ration Potash.	1 ration Potash. ½ ration Soda.	1 ration Soda. ¼ ration Potash.	1 ration Potash. ¼ ration Soda.	1 ration Soda. 0 ration Potash.	1 ration Potash. 0 ration Soda.	1 ration Soda. 1 ration Potash.	¾ ration Potash. ¾ ration Soda.	½ ration Soda. ½ ration Potash.	¼ ration Potash. ¼ ration Soda.
PLOT No.	25	31	26	32	27	33	28	34	29	35	30	36	37	43	38	44	39	45	40	46	41	47	42	48
White Beans—(whole plant dried)	4.3	0.5	3.3	2.1	3.0	2.5	2.8	2.3	4.0	4.0	3.0	4.3	5.8	5.4	3.6	4.5	3.6	5.8	3.0	5.4	4.5	4.5	4.8	3.0
Carrots—(roots)	3.8	6.5	8.8	15.0	6.0	11.0	9.0	8.8	23.0	34.0	5.0	16.0	10.3	19.5	12.0	10.0	4.3	12.0	13.0	44.5	28.0	42.0	28.3	40.5
Beets—Norbiton Giant—(roots)	0.3	0.3	0.8	0.5	0.3	0.8	0.0	0.8	4.4	4.0	0.9	0.1	18.3	14.5	9.4	13.5	14.8	14.6	4.8	19.5	7.3	5.8	18.0	14.5
Beets—Yellow Globe—(roots)	0.3	0.3	0.1	0.3	1.0	0.4	0.1	0.4	3.8	3.1	0.1	0.1	14.0	14.5	14.8	22.6	14.0	9.3	4.8	19.5	19.0	14.3	23.0	18.0
Cucumbers	2.4	16.2	2.8	14.3	1.5	19.3	0.4	16.0	6.8	28.1	8.3	9.6	30.2	65.3	34.1	49.5	18.8	42.7	8.6	66.8	40.8	32.9	29.9	27.9
Sorghum	5.6	6.5	4.8	10.2	2.6	7.5	2.9	3.3	8.4	19.0	4.0	7.5	24.3	17.9	15.5	17.9	12.6	22.5	19.8	45.3	23.8	25.6	19.9	27.0
Millet	9.3	14.9	14.8	19.0	14.8	20.0	11.0	16.1	16.5	20.5	16.5	13.8	24.0	23.5	19.8	21.5	18.0	21.5	13.2	15.3	18.3	14.9	15.0	14.8
Turnips—Rutabaga—(roots)	78.3	66.0	77.5	74.3	75.5	76.5	53.8	78.5	86.5	91.3	68.0	46.4	72.3	89.5	80.0	108.5	76.3	92.3	68.5	98.8	86.8	86.8	79.0	53.0
Potatoes- (tubers)	9.8	7.0	10.5	12.5	10.8	11.3	8.0	13.3	10.5	10.5	13.5	11.8	9.0	10.4	10.9	13.5	12.8	12.0	11.2	9.6	11.2	11.8	10.0	9.0

From an examination of the foregoing tables it will be seen that there was considerable irregularity in the yields, owing, as before stated, to the drought and to the fact that it was the first year of the experiment, while the differences resulting from the various fertilizers employed had not had sufficient time to show themselves in a marked degree. The differences due to manuring would be expected to become more marked from year to year. These results are given here as a record of progress and not with the idea of their serving as a basis for drawing extensive conclusions.

By a comparison of the yields where soda was used without potash with those where potash was used without soda, it will be seen that they were generally greater in the latter case. Again, where potash in increasing quantities was added to a full ration of soda the yields were generally increased, though not always in a uniform degree according to the amount of potash added; on the other hand, where soda in increasing quantities was added to a full ration of potash, the results were generally less satisfactory.

By a comparison of the yields where sodium and potassium chlorides were used with those where carbonates of sodium and potassium were employed, it will be seen that the yields were generally greater in connection with the latter. Those plants which show the greatest benefit from the use of the carbonates are among those which in experiments elsewhere were most benefited by the use of air-slacked lime. That the particular advantage of the carbonates over the chlorides in this instance was due to the fact that the former were decidedly effective in reducing the acidity of the soil seems probable. That the quantities of sodium and potassium carbonates employed were not sufficient to reduce the acidity of the soil in a great degree is probable from the fact that the use of air-slacked lime still further increased the yields of those crops most seriously affected by soil acidity. From what has just been said it is evident, therefore, that the use of lime was advantageous in connection with sodium and potassium carbonates, and *much more so* in connection with sodium and potassium chlorides. It must be evident from the foregoing that if the acidity of the soil were left out of consideration, wholly erroneous conclusions would be drawn.

SUMMARY.

The indications from the experiment this year are that soda was inferior to potash, but to what extent, if any, it is important as a plant nutrient in connection with potash in addition to the soda already existing in our soil, can only be ascertained by a repetition of the experiment perhaps for a number of years. Though the direct object of the experiment was not to compare the action of the chlorides and carbonates of potassium and sodium, it was evident that the latter produced much greater yields with certain crops than did the chlorides, and that this was due to the action of the carbonates in reducing the acidity or sourness of the soil seems probable. A similar beneficial action from the lime in connection with certain plants, which is in accord with previous experiments, is also evident.

HORTICULTURAL DIVISION.

L. F. KINNEY.

During this year field experiments in the treatment of fruit trees to protect them from fungous diseases and the attack of insects have been conducted as follows: At North Scituate an orchard of more than one hundred fruiting apple trees has been sprayed in co-operation with the owner, Hon. Martin S. Smith. This work was done under the immediate supervision of Mr. George W. Burlingame, and the results, as tabulated by him, are nearly ready for publication. At West Kingston, in an orchard of twenty-two bearing pear trees, sixteen were treated with the combined fungicide and insecticide in co-operation with the owner, Mrs. J. G. Clarke. The results of this experiment are now ready for publication. At Glen Rock, a quince orchard, belonging to Mr. D. B. Rodman, was treated for the leaf spot of the quince, and here at Kingston, in an apple orchard belonging to Mr. Samuel Adams, several large bearing trees were treated to detroy the canker worms that appeared upon them. In the College garden several trials have been made with arsenite of lead and Paris green to determine their relative value as insecticides.

From the trial plots in the garden 163 packages of plants have been distributed to residents of the State. In the laboratory thirty-eight samples of seeds have been examined and records made of the vitality of each, as shown by the germination test and the amount and nature of the impurities found in each sample. Some studies have also been made of the fungi that cause the common apple rots, with the hope that a treatment may be found that will enable growers to keep their fruit longer than they now can, particularly after it is gathered, without suffering the heavy losses which at present so frequently occur from the attack of these parasites. In the execution of all of the work enumerated above Mr. George E. Adams has rendered valuable assistance.

FUNGOUS PARASITES OF THE APPLE AND PEAR.

The depredations of certain parasitic fungi are now recognized by fruit growers as matters of sufficient importance to require special attention, and specific treatment is now given in many localities in this State to protect orchard trees and fruits from the attacks of these and insects. Probably in no other way has fruit culture received so much benefit during the last decade as from the diffusion of information concerning the nature of these parasites and the intelligent use of materials which repeated experiments have shown may be applied in a form that will with certainty kill these pests at certain stages of their existence and yet be perfectly harmless to human beings and the higher animals.

The cost of these materials has been shown by many experiments to be much less than the increase in the value of the crop due to their application, and the apparatus for applying them has been so simplified and perfected that there is no longer any doubt about the use of fungicides in the orchard being profitable. As injurious fungi and insects usually occur on apple and pear trees at the same time, it is now a common custom to mix a fungicide and an insecticide together and apply both at a single operation. This being the case, opinions differ concerning the benefits that are derived from the use of the individual ingredients, but it appears at the present time as if the production of fruit of the highest quality cannot be insured without the use of both.

The Bordeaux mixture and Paris green are the materials that are now most frequently employed for this purpose in the orchard, but there are other fungous parasites that follow the fruit from the orchard to the store-room or market, and there often render a large proportion of it entirely worthless, for which we have now no satisfactory remedy. I refer to the fungi that cause the fruit rots, three of which will be mentioned later.

The fruit rots are so familiar to every one that I need only call attention to them here for the reader to realize that they are constantly destroying vast quantities of fruit, and that any means of checking them that could be discovered would be of great value to both the grower and consumer. "Cold storage," it is true, temporarily arrests the development of these parasites, but few growers at the present time have facilities for thus keeping their fruit.

In the following pages it will be my purpose to point out some of the distinctive characteristics of the fungous diseases which, at the present time, seem to be doing the most damage in the apple and pear orchards in this State. Believing that such information will aid growers in distinguishing one disease from another, and also in understanding the nature of the parasite that is the primary cause of each of them, and that this will eventually lead to their most intelligent treatment.

THE SCAB OF THE APPLE AND PEAR.

Fusicladium Dendriticum, Fckl.

So much has been said and written in the last few years about the apple scab that the dark scurfy spots which often occur on the Fameuse, King, Northern Spy and other apples are now generally recognized as injuries caused by the growth of the Fusicladium upon the surface of the fruit. These spots (see Fig. II) are usually rounded in outline, slightly raised above the surrounding surface and often from one-fourth to one-half inch in diameter, or sometimes even more than this when two or more spots have grown together. The injuries do not appear to extend through the skin, although fruit that is attacked while small is frequently dwarfed and more or less deformed, and its appearance is always damaged.

I have also found that the fungi that cause the apple rots are much more likely to penetrate through the skin to the pulp at the spots that have first been injured by the Fusicladium than where no such injury has occurred. This fact should not be overlooked by growers. But the scurfy spots upon the fruit must not be alone considered in estimating the damage done by this parasite in the orchard, for it attacks all the green parts of the apple and pear and occurs much more frequently upon the foliage than upon the growing fruit. Figure I is from a twig of a Maiden's Blush tree, with the under surface of the upper leaf attacked in several places by patches of the Fusicladium. These patches, which are smoky, olive green in color, when thus growing upon the leaves do not kill the tissue beneath them, thus the upper surface of the leaf shown in the figure appeared perfectly sound while the under side was badly attacked. In this respect the Fusicladium differs from the other three fungous parasites that occur on apple and pear leaves that will be described hereafter. The injuries of these extend through the leaves and appear much the same upon both surfaces.

Probably no variety of the apple or pear can be considered as exempt from injury by the Fusicladium, and Early Harvest, Flemish Beauty, and some other trees in this locality are seldom entirely free from it. Baldwin trees are less frequently attacked by this parasite, but their foliage is often injured by the leaf spot (Phyllosticta). I doubt if a single tree in the young orchard of nearly one hundred and seventy varieties here at the College remained completely free from the Fusicladium during the entire summer, although many of them appeared to be free from it when examined at different times. A common form of the spores of the Fusicladium is shown at Figure III, highly magnified. These spores can usually be readily seen, mixed with other matter, by scraping off a little of the dark coating from a well-developed spot on an apple or a leaf and examining this under a compound

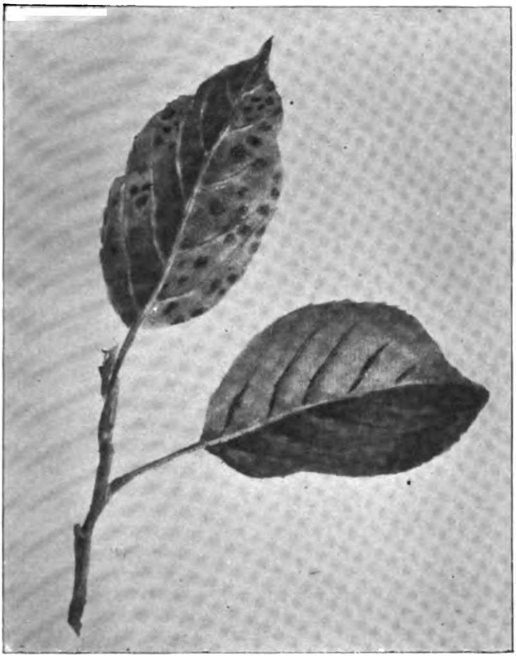


Fig. I. Twig from Maiden's Blush tree with patches of Fusicladium on the under surface of the upper leaf.

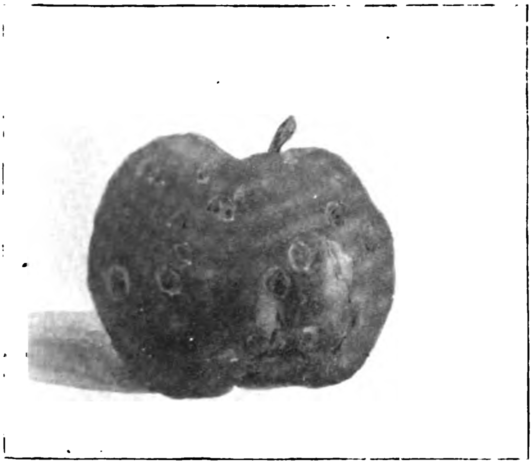


Fig. II. Greening apple with scab spots.

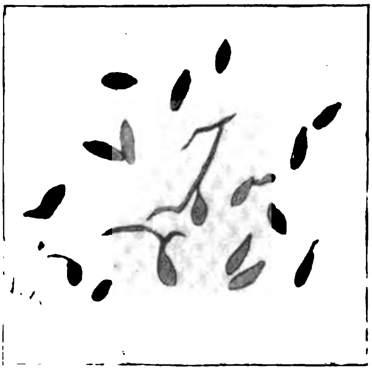


Fig. III. Fusicladium spores from surface of an apple. (Magnified.)

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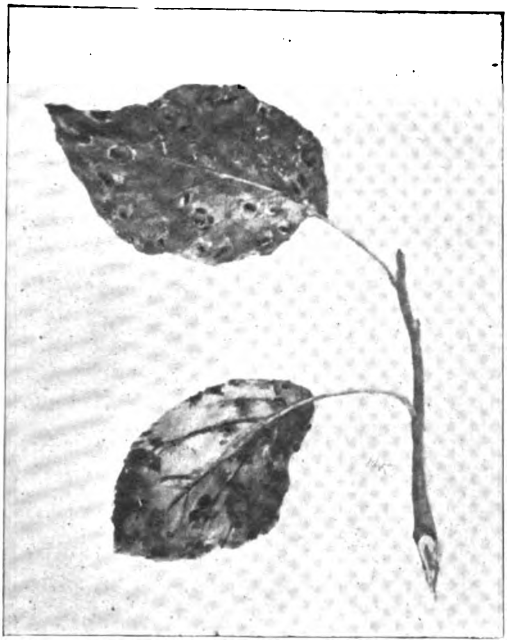

Fig. IV. Twig from Quaker Beauty tree attacked by apple rust.

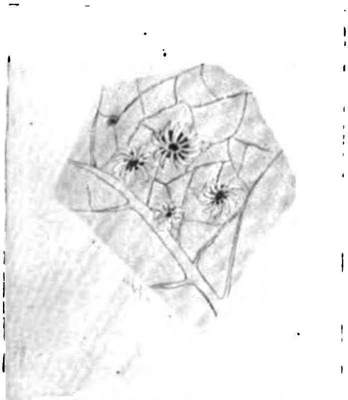

Fig. V. Section of leaf attacked by apple rust showing cluster cups. (Somewhat magnified.)

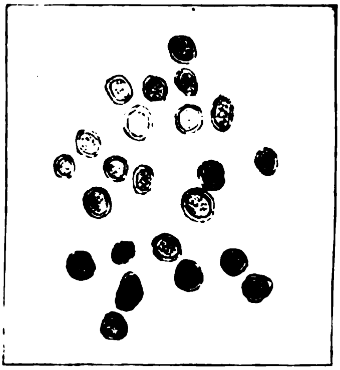

Fig. VI. Spore of fungus causing apple rust. (G. macropus.)

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microscope of moderate power. A technical description of the apple scab, with colored illustrations and bibliography, can be found in the Report of the Department of Agriculture for 1887, page 341 and following.

THE APPLE RUST.*

Gymnosporangium macropus, Lk.

The apple rust is so entirely distinct from the scab of the apple and pear that the injuries of the two cannot possibly be confused by anyone who has once become at all familiar with them. The orange color alone of the rust spots upon the foliage seems to be sufficient to enable one to recognize this disease, sometimes even at several rods distance.

Wild trees in pastures and by roadsides, and those of cultivated varieties that grow in the immediate vicinity of red cedar or savin (*Juniperus Virginia, L.*), are the ones upon which the rust most frequently occurs, although its injuries are by no means confined to these, and I doubt if there are many orchards in this State that are not annually more or less damaged by it. The Rhode Island Greening is a common host of this parasite, and during the past season I have seen many trees of this variety, the foliage of which was so badly attacked that the fruit never fully matured. Figure IV is from a twig of a Quaker Beauty tree that was attacked by the rust. The yellow spots upon the leaves, the appearance of which can be but poorly represented by a photograph, extend through the tissue, making it somewhat thicker than the normal condition and can be seen alike from the top and bottom. They are not, however, exactly the same on both surfaces, and if closely examined, several slight projections will usually be found on the under side of each spot. These are the cluster cups in which the spores are borne.

Figure V. shows a rust spot somewhat magnified, with four

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*Under this name the injuries of several species of *Gymnosporangium*, of which *G. macropus, Lk.*, seem to be most common, are included.

mature cluster cups upon it. The appearance of the spores when highly magnified is shown at Figure VI. These shake out easily from the cups when they are mature, and can readily be collected for examination upon any smooth surface. As already stated, the rust is most troublesome in the vicinity of cedar trees. This is because one stage of the parasite that causes it, the *Gymnosporangium*, is passed upon the cedars, producing upon them the peculiar growths known as "cedar apples," and from these it is communicated to apple trees. It is, therefore, apparent that all worthless, straggling cedar trees in the vicinity of orchards should be cut down and destroyed. A technical description of this disease, with colored plates and bibliography, can be found in the Report of the Department of Agriculture for 1880, page 370 and following.

THE LEAF SPOT OF THE APPLE AND PEAR.

Phyllosticta pyrina.

As the name implies, the injuries of this orchard pest, as they are at present understood, occur in spots upon the foliage of the apple and pear. At these spots the tissue appears to be killed by the action of the parasite, and usually turns first a brown and later a grayish color. It also soon becomes thin and brittle, while the surrounding tissue remains in an apparently natural condition. When once familiar with the appearance of the leaf spot, it is readily distinguished from either the rust or the scab upon the apple, but less easily upon the pear from the leaf blight, the injuries of which in some stages much resemble those of the leaf spot. It should be mentioned here, also, that the injuries of a common green worm, an apple-leaf miner,* are sometimes mistaken for the leaf spot. It does not, however, usually require a very close examination to either find the worm or the cavity in which it has lived. Most frequently, too, the spots produced by

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* Probably the one described by Saunders as *Tischeria Malifoliella*, Clemens, in his "Insects Injurious to Fruits," page 114.

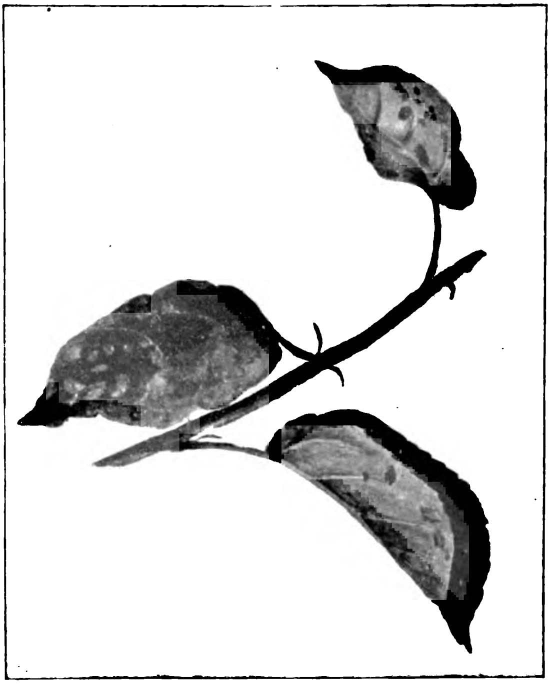

Fig. VII. Twig from Red June tree attacked by leaf spot.

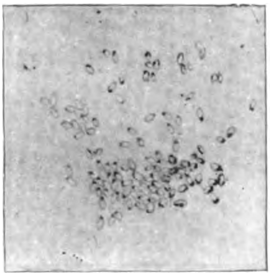

Fig. VIII. Spores from a leaf spot.

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worms are brown only on the under side, while those produced by the leaf spot are about the same upon both surfaces.

Figure VII. is from a twig of a red June tree, the leaves of which were attacked by the spot. In this figure the upper surface of the central and the lower surface of the upper leaf are shown. Very small spores are found in great numbers in the black specks that occur in the spots. These appear when highly magnified, as shown in Figure VIII.

The leaf spot is very common upon the leaves of the apple and pear in this State, and no argument should be necessary to convince growers that it is an advantage to their trees to protect them from it.

THE LEAF BLIGHT AND CRACKING OF THE PEAR.

Entomosporium maculatum, Lév.

Attention was called to the leaf blight in Bulletin 27 of this station, where the results of an experiment in the treatment of several trees to protect them from it were reported. Another year's experience since this bulletin was published has furnished additional evidence that many trees that have been non-productive for years, due to the annual attack of the *Entomosporium*,* the fungus causing the leaf blight and cracking of the pear, can be made by intelligent treatment to produce fruit of the finest quality.

The presence of the *Entomosporium* is indicated both upon the foliage and fruit, in its early stages of attack, by small reddish spots with dark centers. These spots extend through the tissue of the leaves, and are often from one-sixteenth to one-eighth of an inch in diameter. Later the color gradually disappears from the spots and the tissue becomes dry and papery. The appearance of a twig from a Margaret tree, September 4th, that was attacked by the leaf blight, is shown in Figure IX.

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* The *Fusicladium* often occurs upon trees with the *Entomosporium*.

The *Entomosporium* is even more destructive in its action upon the fruit of some varieties of pears than upon the foliage. Here it causes what is known as the "cracking of the pear," and not infrequently the fruit of certain kinds is attacked so severely that scarcely a pear on a tree will escape being ruined by it.

While the leaf blight occurs upon the leaves of many varieties of pears, fortunately it seldom causes the fruit of but few kinds to crack open. It may, however, produce hard, dry places on the surface and cause the fruit to grow deformed where no "cracking" occurs. I have frequently seen Seckels thus injured.

The spores of the *Entomosporium* are very small, nearly transparent, and often not easily found, even under a good microscope. In Figure X. several of these are shown considerably magnified.

It sometimes happens that pears crack badly on trees that appear to be attacked only by the *Fusicladium* (scab). Such a case is illustrated in Figure XI., which is from a twig of a flemish beauty tree. Here the greenish patches of the *Fusicladium* nearly covered the under surface of many of the leaves and were thickly scattered over the fruit, while very little of the *Entomosporium* could be found upon the tree. Still the fruit cracked, as shown in the figure, and I am at present inclined to believe that this was mainly, at least, due to injuries that were caused by the growth of the *Entomosporium* early in the season, and which became indistinct and were almost entirely concealed later by the growth of the *Fusicladium*. These parasites are often found growing together upon the same tree, but usually, in the cases that I have noticed where the fruit cracked deeply, more *Entomosporium* has been found upon the leaves. For a technical description of this disease the reader is referred to the Report of the Department of Agriculture for 1888, page 357.

REMEDY AND TREATMENT FOR THE FOREGOING DISEASES.

With our present information concerning the parasites that cause these diseases we cannot expect to secure complete protec-

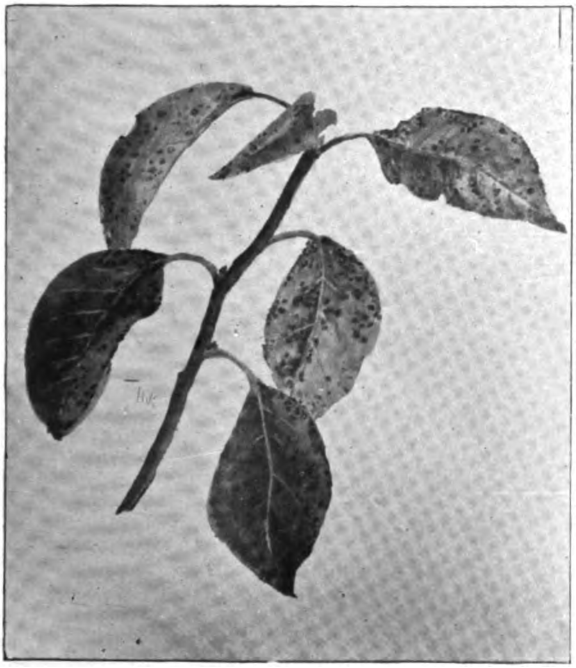

Fig. IX. Twig from Margaret pear tree attacked by the leaf blight.

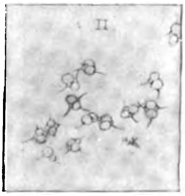

Fig. X. Insect-like spores of Entomosporium. (Magnified.)

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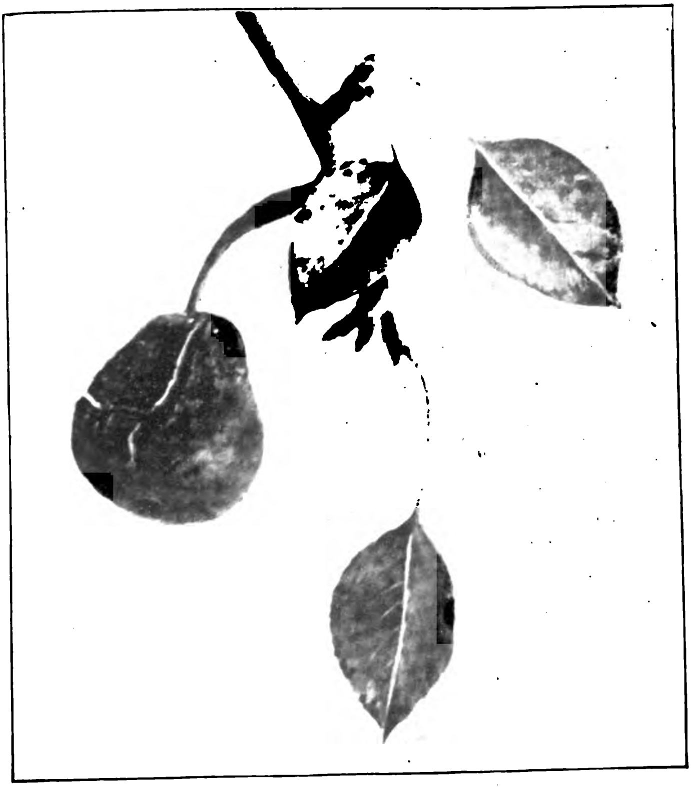

FIG. XI. From a twig of a Flemish Beauty tree cut Sept. 5th.

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tion from them by any cultural methods or special fertilization, although these matters should not be neglected; for it is in orchards that have been most thoroughly pruned, fertilized and cultivated that these diseases have been most successfully treated. Fortunately, we have in a single substance, the Bordeaux mixture, a simple, inexpensive and easily-prepared remedy for, or at least preventive of, the worst of the diseases, viz.: the scab of the apple and pear, and the leaf blight. It will also probably prove valuable in checking the rust and leaf spot, although I am not aware that this has yet been established by experiment. The Bordeaux mixture has now been used by thousands of persons, and its value as a fungicide has been thoroughly demonstrated.

Directions for making the Bordeaux mixture have been given in previous publications of this station, but for the convenience of any who cannot easily refer to these the formula may be repeated here. It is as follows:

Six pounds of sulphate of copper,
Four pounds of caustic lime,
Twenty-two gallons of water.

The copper should be dissolved and the lime slacked in separate receptacles, and then they can be poured together and diluted with the remaining water. The amount of water in this formula may be increased to thirty or forty gallons, and often nearly or quite as good results have been obtained from the application of the mixture in these more diluted forms. If the ferro-cyanide of potassium test is used in making the Bordeaux mixture, an excess of lime should always be added.

Upon application to the Experiment Station more complete directions for making the Bordeaux mixture will be furnished.

The most satisfactory treatment that is now known for the prevention of these diseases is to apply the Bordeaux mixture in the form of a spray to all the green parts of the tree or trees that are to be protected. Both the upper and under surface of the leaves should be thoroughly wet if the most complete protection is desired. From three to six applications are now generally made, the first of these being before the blossoms open, the second soon after the blossoms (petals) fall, and the others, as many as may be necessary, at intervals of from two to three weeks. Some kind of a force pump is always used in the operation. Of these there are now several patterns upon the market that are well adapted to the work.

THE APPLE ROTS.

It appears that there are, at least, three fungous parasites that attack ripe or nearly ripe apples and cause the rapid decay of the tissue. All of these produce a brownish discoloration and softening of the skin and flesh, and in time, if not interrupted, penetrate through the entire apple. The spores, by means of which these parasites spread from apple to apple, are formed in enormous numbers on the surface of the decayed spots, and are carried from place to place by various agencies, but probably very largely by insects that collect about decaying or otherwise injured fruit in search of food. I noticed one species of very small flies* in particular last Fall that seemed to be very active in distributing these spores.

THE BROWN ROT.

Sphæropsis malorem, Pk.

Apples attacked by the brown rot soon turn a light brown color, and then frequently remain for some time but slightly changed in size or form. Often the tissue is but little softened, and although very insipid, is not otherwise very disagreeable to the taste. This rot may be recognized by the black pimples that soon appear just beneath the surface and the olive green spores that escape later through a roundish opening in the top of each of these. Sometimes these pimples are so numerous that they impart a dark color to a part or the entire apple.

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* A pomace fly, *Drosaphila Ampelophila.*

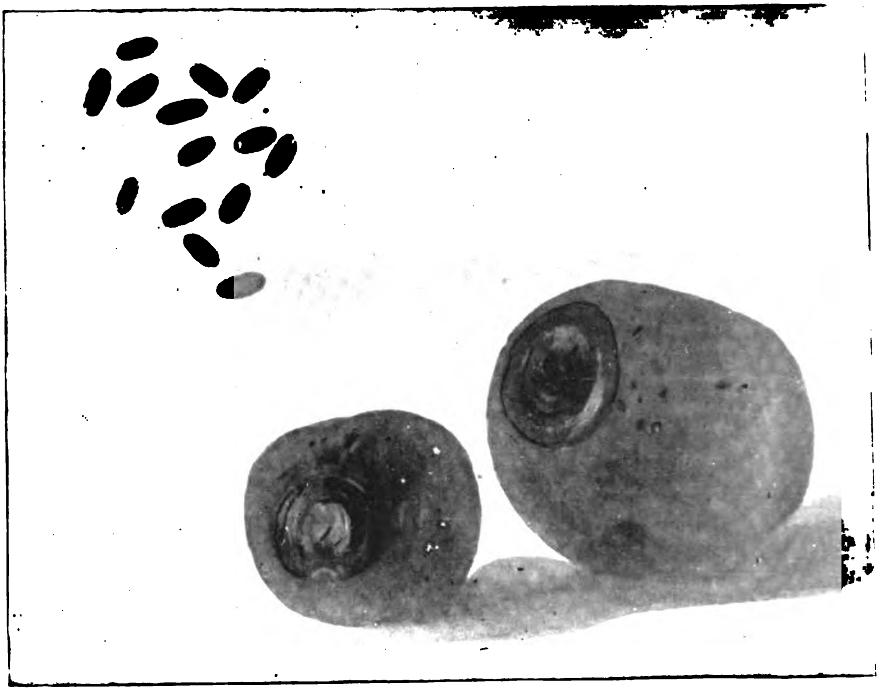

FIG. XII. Greening apples attacked by the brown rot with several spores of the Sphæropsis, highly magnified.

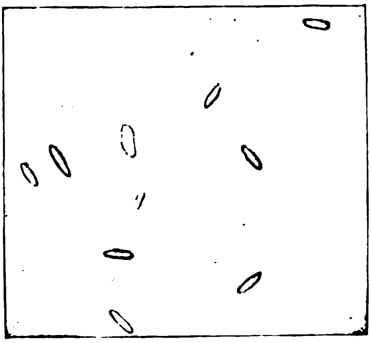

FIG. XIII. From photo-micrograph of spore Gleosporium fructigenum, the fungus causing the ripe or bitter rot.

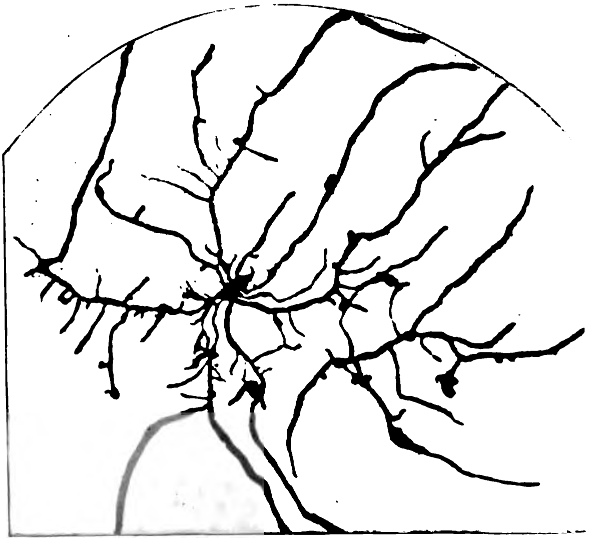

FIG. XIV. From a photo-micrograph of one week's growth of Mycelium from spores of Gleosporium in water.

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Figure XII is from two Greening apples, each one having a spot of the brown rot upon it. In the upper left hand corner of the same figure several spores from one of the pimples are shown, highly magnified. This was the most common rot upon the summer and early autumn apples in the orchards in this locality last season, but later I noticed it only rarely upon winter apples.

THE RIPE OR BITTER ROT.

Glœosporium fructigenum, Berk.

This rot resembles the preceding very closely in general appearance, but can be distinguished from it by the dark or nearly black specks that begin to appear on the surface in from five to eight days after an apple is infected. These specks are unlike the pimples that appear on the surface of the brown rot (in about the same time) in being less nearly spherical in outline and in opening by longitudinal ruptures instead of pores at the top. The spores also of the bitter rot, when seen through the ruptures in a mass, have a pinkish color that is characteristic in this connection of this rot.

Figure XIII is from a photo-micrograph of several of these spores. This form of the ripe or bitter rot spores is easily obtained in a nearly pure condition, and when a requisite amount of moisture and heat are present they begin to germinate at once. Within a few days, long, slender threads (*mycelium*) are sent out in all directions from groups of these, and it is the growth of these threads through the tissue of the apple that causes the apple rot. An examination of Figure XIV may help the reader to understand more clearly the actual appearance of the *mycelium*, and also to associate with its development the breaking down of the cells of the apple. This figure is from a photo-micrograph of a culture of the *mycelium* in clear water, showing one week's growth from groups of spores. In water the *mycelium* continues to grow until a complete mat is formed, and in the tissue of the apple the growth is probably even more rapid and the branching more diffuse.

Several times during the past season these spores have been introduced into sound apples, but I will mention here only a single series. This included twelve inoculations, which were made Oct. 5th, 1894. The conditions may be briefly stated as follows: Four Greening and four Baldwin apples were selected in the orchard, thoroughly washed in water and suspended by fine wires in glass specimen jars. When thus arranged they were all removed from the jars with the covers and placed in a row upon a table. Three incisions, at about equal distances apart around the centre, were then made in each apple with the point of a jack-knife, excepting number six in the row, which was accidentally passed over; then, beginning at the end of the row where the Greenings were placed, fresh spores from an apple that had been previously inoculated were introduced into all of the incisions in each alternate apple. The covers with the apples were then returned to the jars, and these were set away in the laboratory. Four days later, Oct. 9th, signs of decay could be seen about every one of the twelve incisions where the spores were introduced, while they were entirely absent from the nine other places where the knife point was inserted but where no spores were introduced. At this time the decay was indicated by the discoloration of the skin for about one-sixteenth of an inch around the cuts made by the knife.

Eight days after the spores were introduced, Oct. 13th, the decayed spots were oval in form, the longer diameter measuring about three-fourths of an inch (see Fig. XV). At this time the dark specks had appeared on the surface of nearly all of the spots, and on some of them they had ruptured and the spores were exposed. During the following week the size of the decayed spots increased rapidly, so that they appeared, Oct. 20, as shown in Fig. XVI. Up to this time there was scarcely a sign of decay about any of the places where the knife point was inserted but no spores were introduced. The skin had hardened around the edges of the cuts, while beneath it the tissue was perfectly sound.

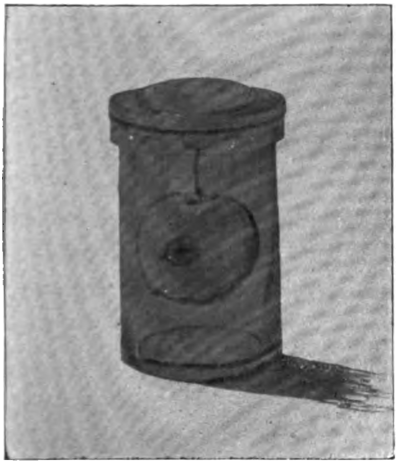

FIG. XV. Appearance of apple inoculated with Gleosporium spores eight days after the spores were introduced under the skin.

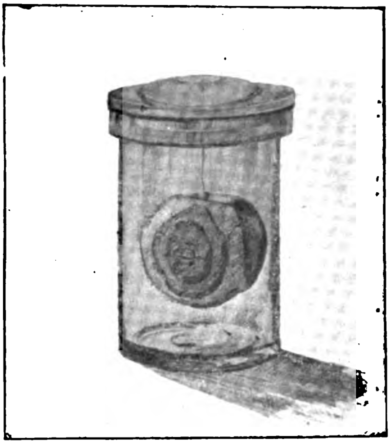

FIG. XVI. Appearance of apple inoculated with Gleosporium spores after fifteen days.

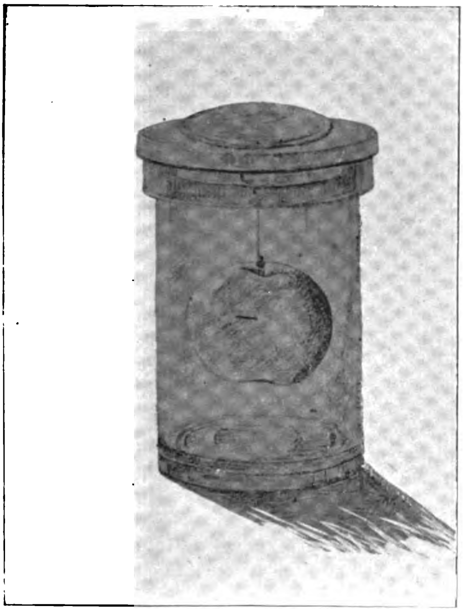

FIG. XVII. Appearance of apple that had no spores introduced into the cut fifteen days after the cut was made.

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The appearance of one of the cuts is shown in Figure XVII. No further observations were made after Oct. 20th, for at that time the decayed spots had commenced to merge into one another, and the jars having been opened several times, other fungi began to appear.

This rot appeared to be destroying more fruit in the orchards in this vicinity during last October than any other, and I have occasionally found it upon apples that have been stored since then, but less frequently after the weather became cold than the following. For further information concerning the ripe or bitter rot the reader is referred to an article by Miss E. A. Southworth in the Journal of Mycology, Vol. VI., No. 4, page 164.

THE BLUE MOULD.

Penicillium glaucum.

In its first stages this rot resembles in appearance the others already mentioned, but may be distinguished from them later by the out-growth through the surface of tufts of slender white threads that bear upon their tops globular masses of small round spores. These heads are light blue in color, and can be readily seen. They appear first near the point where the apple became infected, and later, as the rot develops, all over the apple.

Figure XVIII is from a photograph of a decayed Baldwin, showing its appearance one month after being inoculated with blue mould spores. This apple having been kept in a glass jar, all of the spores produced by the mould remained upon it until the time photographed. More frequently it happens that the spores are separated from the apple, from time to time, as they mature, so that only a comparatively small number of heads of spores are seen upon the surface of the decayed fruit at once.

The spores of the blue mould have been repeatedly placed in a break in the skin of Greening, Baldwin and Roxbury Russet apples, which have been immediately suspended in glass jars, and without a single exception, decay has always followed such inoculations. Usually the decay has spread through the entire apple in from two to four weeks.

In a number of cases six punctures were made at about equal distances apart around the circumference of apples, and then spores of the *Penicillium* (blue mould) were introduced into every other one of the punctures. Here, as elsewhere, decay always followed where the spores were introduced, while the incision made by the knife remained unchanged until infected from one of the adjoining spots or some other source. Figure XIX is from a photo-micrograph of *Penicillium* spores.

The skin of unripe apples, when perfectly sound, is a natural protection against the attack of these rot-producing fungi, and while under some conditions they may be able to penetrate through it, they appear to seek to reach the more tender flesh beneath through some place where it has been previously broken or at least injured. From the examination of several hundred autumn and winter apples in the orchard last Fall, I conclude that the starting points of these common rots can most frequently be traced to injuries caused by the larvae of the codling moth, and secondly to injuries caused by the *Fusicladium* or scab-producing fungus. It should be remembered in connection with this that spraying the trees early in the Spring, as previously mentioned, mainly controls the attack of both of these orchard pests, and therefore it must indirectly prevent the apples from rotting. But even with the present approved use of fungicides and insecticides in the orchard, and the practice of the most careful methods of harvesting, the apple rots do annually attack and spoil thousands of barrels of excellent fruit. In this lattitude, at least, a large proportion of this damage occurs after the fruit is taken from the trees, although it appears that the spores of the rot-producing fungi may be adhering to the surface of the apples at the time they are picked and only awaiting favorable conditions for their germination. The moisture that accumulates on the skins of apples when they are gathered and placed in heaps or in barrels, is favorable to the growth of these spores, and in some way thick-

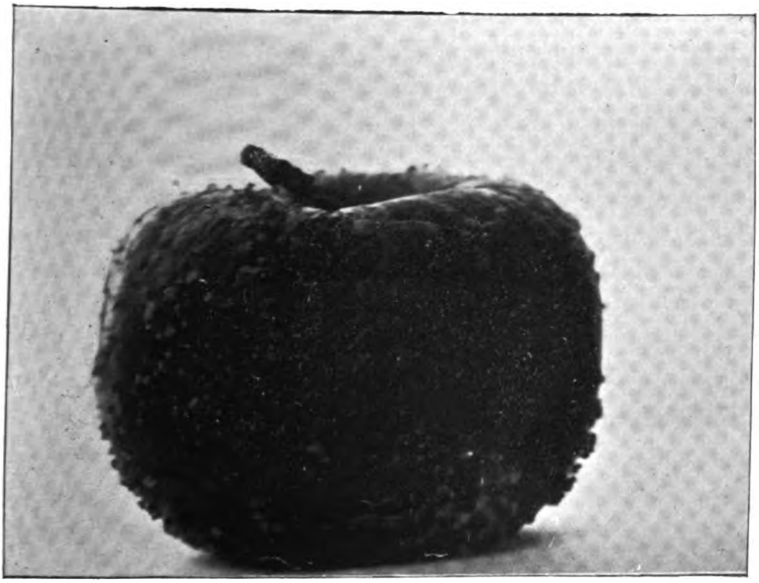

Fig. XVIII. Appearance of a Baldwin apple one month after being inoculated with Penicillium spores.

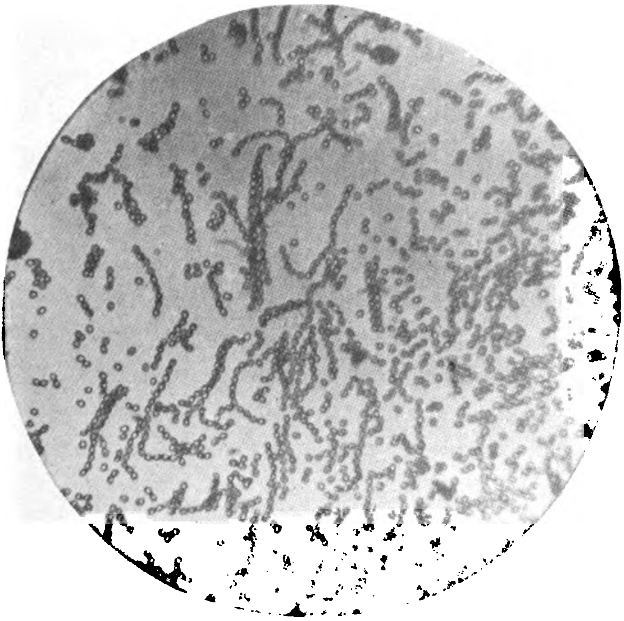

Fig. XIX. Penicillium spores from surface of an apple. (From photo-micrograph.)

UNIV. OF MICH.

skinned apples that appear to be perfectly sound and unripe when stored in the ordinary manner, often become infected one after another with some of the rots, and finally decay. It is, of course, probable that spores from a decaying apple in a barrel or heap may spread to other sound fruit and that in this way the rot may be propagated, but I have found, by placing apples in tight glass jars immediately after they were taken from the trees, that the rot also often develops upon them, and frequently this has not occurred until two or more weeks after the apples were enclosed in the jars. In these cases there was no opportunity for the germs to be communicated to them from without, and as the apples showed none of the signs of decay which always followed where inoculations were made, either when they were placed in the jars or for some time afterwards, I conclude that the spores, or any slight growth that might have developed from them, must have been at the time the apples were picked entirely outside of the skins. If this should, upon further investigation, prove to be the case, it seems quite possible that some simple method of disinfection may be found which will, with proper protection from contamination afterward, considerably prolong the time that apples may be kept in a fresh and edible condition. It has been with this object in view that our observations have been made upon the growth of the rot-producing fungi, although up to this time no treatment has been found that can be recommended.

No special field treatment for the prevention of the apple rots has been given here, although it has been shown by Curtiss* that the ripe or bitter rot, at least, can be very largely controlled by spraying the fruit while it is growing with a solution of potassium sulphide in water (one-half ounce to the gallon), and more recently Garman† has used the Bordeaux mixture with marked success in the orchard treatment of the same rot. It appears, however, that there may be objections to the general use of either of these substances for this purpose, and it is for this reason that we have been looking for a better method of treatment that will be free from these objections and furnish more protection for the apples after they have been taken from the orchard.

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* George G. Curtiss, Bulletin 11, Div. Veg. Pathology, Dept. of Agriculture, page 38. Mr. Curtiss also used the ammoniacal solution of carbonate of copper at the same time with good results.

† H. Garman, Bulletin 44, Kentucky Expt. Station.

POULTRY DIVISION.

SAMUEL CUSHMAN.

AN INFECTIOUS DISEASE OF TURKEYS.

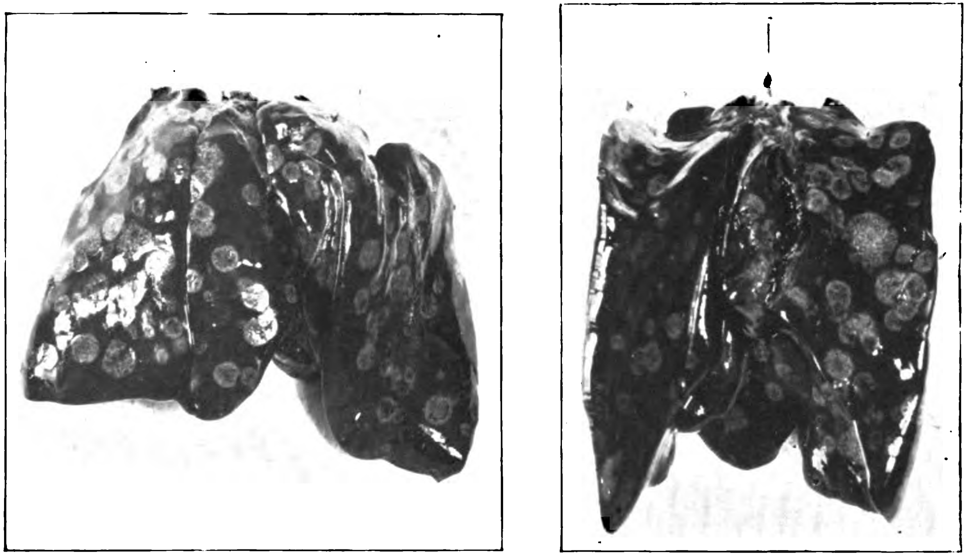
The study of the diseases of turkeys has been continued the past season. The portions of diseased livers and bowels sent by this Division to the U. S. Bureau of Animal Industry in October, 1893, and March, 1894, convinced the experts of the Bureau that the trouble was of an infectious nature, and the Chief of the Division of Animal Pathology inquired if the disease was prevalent enough among turkeys in this State at certain seasons to keep a specialist busy for several weeks making autopsies, cultures and microscopic examinations of tissues without too much travelling and waste of time. He was informed that the disease was very prevalent among turkeys at certain seasons, that in no section of the country were so many large flocks of turkeys to be found as in the vicinity of this Station, and that if an expert was sent on to investigate the disease this Division would undertake to supply him with all the diseased material that was desired. The office of this Division was also offered for the use of the investigator, and he was promised all possible aid. After some correspondence we were informed by Dr. Theobald Smith, in a communication dated July 7th, that a representative of the Bureau would be detailed about August 1st to spend three weeks in this State investigating the infectious disease of turkeys. On July 15th, Circular Bulletin No. 2, on the "Black Head of Turkeys," giving symptoms of the disease and requesting the co-operation of farmers and turkey raisers in seeking out and securing cases of the disease, was sent out. Any one having had experience with either "black head" or tape-worms of turkeys was also asked to communicate with this Division. Few specimens were sent in by turkey raisers, owing to the apathy of many farmers among whose turkeys the disease prevailed, also to the fact that at this time the disease had not developed serious symptoms in many flocks, on account of the favorable dry weather.

While the Circular Bulletin secured few responses, a personal application made to the owners of the flocks always secured their cordial assistance. By driving about the country and inspecting every flock of turkeys that could be found, and at once catching or aiding in catching those selected as possible cases, sick birds were secured alive from a good number of flocks, enough to provide the Government expert with all the material that he could use.

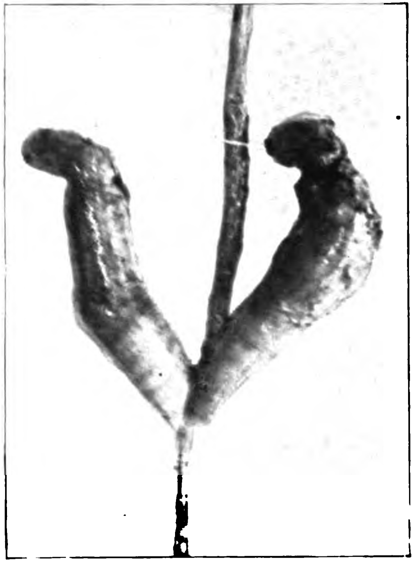
Dr. Theobald Smith, Chief of the Division of Animal Pathology, was detailed by the Secretary of Agriculture for this work. Very careful post mortem examinations were made on over fifty young turkeys, and the intestines of twenty-five more. The throat, trachea, lungs and liver were examined, as well as the entire length of the alimentary canal. Many cases were found in various stages of the disease. Dr. Smith made a microscopical examination of the blood of each live turkey and the tissues of the organs, as well as starting from the blood and tissues bacteriological cultures in tubes. As a result he found that the hitherto undetermined disease of turkeys was due to a micro-organism belonging to the protozoa, which places the malady among the infectious diseases, so that the idea that it is tuberculosis or due simply to improper feeding must be given up.

The disease apparently first attacks the cæcum or pronged part of the lower bowel, which eventually becomes thickened and enlarged, and often badly ulcerated. The liver is next affected, becomes spotted and in advanced stages is covered with circular yellowish areas, showing destruction of tissue within the organ

AN INFECTIOUS DISEASE OF TURKEYS.



Diseased liver from young turkey, showing the circular areas where the tissue has been destroyed by the micro-organism. One of the worst cases.



Cæca or prolonged parts of the lower bowel. Each cæcum enlarged, thickened and ulcerated.

(see illustrations). The disease attacks young turkeys at all ages and gradually develops. More turkeys succumb to it in the latter part of July and early part of August, and at the approach of cold weather in the Fall, than at any other time. Diseased birds seem to be able to hold out against it during the warm, dry weather, but are quickly overcome in wet, stormy weather. Affected birds usually have a diarrhœal discharge, their feathers become rough, and the head looks pinched and turns dark or purple. How turkeys receive the infection and how the infectious organisms may be most easily reached and destroyed, has yet to be determined. Dr. Smith has been able to take back many specimens of diseased tissues for further study, as well as photographs of the diseased organs. Several live turkeys suspected of having the disease, which afterwards proved to be the case, have since been shipped to the Bureau. We understand that investigations in this direction will be continued, and that the results will be published by the U. S. Department of Agriculture. It is known that this disease is not confined to Rhode Island, but is also prevalent in Massachusetts, Connecticut and other parts of New England, and probably extends over a much wider area. Dr. Salmon, Chief of the U. S. Bureau of Animal Industry, desires to determine whether this disease is general throughout the country, and turkey raisers everywhere who have reason to believe that their turkeys are affected should address him at Washington, D. C.

As this is an infectious disease and may in time extend to any part of the country, the importance of finding out all that is possible about it, that means may be taken for stamping it out, is very evident. As the eradication of this disease would be worth hundreds of thousands of dollars to Eastern farmers alone, it is to be hoped that a solution of the problem may soon be reached.

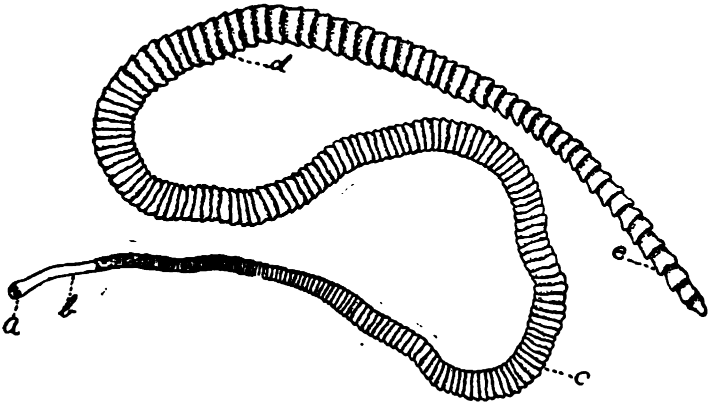
PREVALENCE OF TAPE WORMS IN TURKEYS.

In the Fall of 1893 we found, by dissection and from inquiries among turkey raisers, that young turkeys were infested with tape worms, and in the Sixth Annual Report of the R. I. Experiment

Station, page 288, attention was called to the nature of tape worms and their injurious effect on sheep. The remedies found most effective in removing them from animals were also given.

Tape worms are defined as flat worms having a head and many segments. They have no mouth or alimentary canal, but receive their nourishment—the digested contents of the intestines of their host—by absorption. The head is provided with suckers, and in some groups with curved claw-like hooks, by which it attaches itself to the lining of the intestines. The segments or joints are gradually formed next to the head, and on account of the formation of new segments, are pushed farther from the head, gradually become central and finally become terminal. Each adult segment contains complete male and female organs, and when mature, is full of embryo tape worms. When the embryos mature the ripe segments separate and pass away. The embryos of most species eventually find their way into some intermediate host, where they must pass a certain stage of their development before they are taken in by their final host.

When dissecting turkeys with Dr. Smith for evidences of the "black head" disease, we were very particular to examine the intestines of each bird, the entire length, for tape worms, and found that they were more generally infested than we had even suspected. Turkeys affected with "black head" were free from tape worms, but of the sixty-five examined that showed no traces of that disease the intestines of forty contained tape worms. Worms from a quarter-inch to several inches in length were found, and occasionally those a foot or more long. Some birds contained great numbers of very minute worms in the duodenum, others only large, fully-developed worms in the lower intestine, while in still others small ones were found in the upper intestine and numbers of long and large ones in the lower intestine. In one or two instances these worms were found only in the cæcum or blind prolongation of the lower intestine. One bird, found in a dying condition in a flock from which turkeys had been dying for over a month, and from which thirty had been lost within a week, was found to contain a very large number of tape worms of medium size, and no other cause for sickness could be discovered. Frequently the lower part of the intestine was fairly crowded with great numbers of long worms. One little turkey three or four weeks old had many small worms in the duodenum, and the remainder of the intestines were almost completely filled with those that were several inches long, about fifty in number (see illustration). A microscopical examination of apparently ripe segments by Dr. Smith showed that mature embryos were present.



TAPE WORM FROM A TURKEY.

Illustration of one selected from about fifty found in a turkey three or four weeks old. There is so little known about tape worms of fowls, and so much confusion as to description and classification, that experts have been unable to identify it. *a*, head; *b*, neck; *c*, *d* and *e*, segments in various stages of development. The segments or joints are formed next to the head, are gradually pushed back by the growth of new segments, and finally become terminal (*e*), where they mature, separate and pass away. Each adult segment contains complete male and female organs, and when it separates from the main body, is full of embryos, which are supposed to find their way into some temporary host before they reach their final host, the turkey.

As these sick turkeys came from many different farms in various parts of the State, and but one or two, and no more than four, were secured from any one place, it seems that this trouble is very prevalent among young turkeys during the summer months. We are convinced that it causes the death of great numbers of little turkeys, and that some suitable worm medicine should be frequently given them throughout the season. Turkeys are troubled with tape worms from early Spring until late in the Fall, and sometimes have spasms from this cause. Very young turkeys suffer the most. After they are three months old they are better able to withstand the injurious effect. The worms apparently irritate the bowels, cause digestive derangement, diarrhœa, weakness and death. At certain seasons segments of worms may be found early in the morning under the roosts among the droppings of the infested turkeys. Evidently the younger they receive the parasites the worse they suffer. Doubtless if they survive until the embryos have developed and have mostly passed out, they may gradually recover. A few worms may do little harm, while a great number may be fatal.

How the young receive the embryos in the Spring is an interesting question. Whether snails, worms or insects harbor them and thus scatter the infection, or whether they receive the infection from the droppings of old turkeys, is yet to be determined.

Dr. Stiles of the U. S. Bureau of Animal Industry says that ten different species of tape worms from chickens are described by investigators, and that according to certain Italian authors, one species passes its larval stage in the house fly. Another species has, it is said, for its intermediate host various slugs, while another has a snail as its host. Dr. Salmon thinks it will be found that earth worms, insects and snails are the intermediate host for these tape worm embryos, and that there is at present no ground to think they will be able to develop without some intermediate host.*

A knowledge of the complete life-history of the tape worms found in turkeys would be of great value in prescribing measures for preventing infection. Specimens of tape worms found in turkeys have been sent to Dr. Stiles by this Division. Various species were also carried back by Dr. Smith, and we hope that the active co-operation of the Bureau in this direction will again throw light on problems relating to the turkey raising industry.

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* See Hosts of Tape Worms of Sheep, and Gape Worms of Poultry, 6th Annual Report of R. I. Agrl. Expt. Station, pages 291 and 299.

In whatever way young turkeys receive the embryos of these parasites, doubtless they may be promptly freed from them and any injurious results prevented by the frequent use of simple worm medicines in their food or water.

MEASURES FOR PREVENTING TAPE WORMS.

The longer infested turkeys have been kept on a farm, and the greater the number annually grown, the more thoroughly will tape worm eggs be sown upon the land, and if slugs, snails and earth worms are their intermediate host, the more generally will they contain infecting embryos. Where there have been no tape worm eggs, snails and earth worms will not harbor the embryos, and young turkeys will not become infected in this way. If we can keep turkeys free from worms, we will prevent them from sowing the seed for the tape worm crop, therefore dosing the breeding turkeys in the Winter and Spring would be a preventive measure. Raise the little turkeys on fresh, uncontaminated land, that chickens or other turkeys have not run upon for years, and give them an occasional dose which will destroy tape and gape worm embryos. Give up keeping turkeys, either old or young, on infested ground for several years. Confine infested flocks to an enclosure, and treat them with worm medicine until they are free from worms; meanwhile frequently disinfect the ground in the pen to destroy the eggs that pass off. Then move them to new ground. If it is found that wild birds or any of the animals that wander over the same ground harbor the same tape worms, additional measures will have to be taken to entirely stamp out the infection.

Which of the well-known remedies for tape worms in animals is best suited to the turkey, and what amount should be given to turkeys at different ages, are questions that naturally arise. Until we can advise on this matter from knowledge gained by practical experience we leave it for turkey raisers to test for themselves. Probably the best results may be expected from the use of *freshly powdered* Kousso, or Casso. According to the U. S. Dispensatory the treatment for a human being is, for an adult, half an ounce; for a child of six years, one-fourth ounce, taken in the morning upon an empty stomach. A previous evacuation of the bowels is recommended, and should the medicine not act on the bowels in three or four hours, a brisk cathartic should be administered. One dose is usually sufficient to destroy the worms. Should the quantity mentioned not prove effective, the dose may be doubled. Kousso seems to act only as a poison to the worms, and is said not to seriously affect the patient. Koussein, or Kosin, the active principle prepared from Kousso, is also highly recommended, *two scruples* being the dose for a man. Male Fern is an effective remedy, but an over-dose is a distinct poison. Six drams of the oil have caused the death of a person. It has been known to cause blindness in the lower animals. It is often given in combination with castor oil. Tansy is much used as a preventive of worms. Powdered areca nut is much used for tape worms in dogs and other animals, and frequently in combination with Male Fern. Ground pumpkin seed is also used as a remedy. The dose would have to be much reduced for turkeys. Turkey raisers may administer very light doses to a few turkeys and larger doses to others, and thus learn how great a quantity may be given to healthy turkeys with impunity. It is to be hoped that many may be able to apply these remedies with success, and immediately prevent the loss of their turkeys from this cause. Assafœtida, which is highly recommended for preventing and overcoming the gape worm disease of fowls, is also said to possess virtue as a tape worm remedy. This may be administered in the feed or water. M. Megnin of France gave each pheasant seven and one-half grains of assafœtida combined with the same quantity of pulverized gentian in their feed, and overcame the gape worms. Turpentine administered in slight quantities in the food or water may possibly also enable the turkey raiser to kill both parasites "with one stone."

TURKEYS INFESTED WITH GAPE WORMS.

The trachea of a number of the young turkeys examined was infested with gape worms. In one six pairs were found, and from one to three pairs in the others. A number were infested with both gape worms and tape worms. These turkeys were over three months old, and were too large to be seriously affected even by a much greater number. Gape worms are most destructive when the turkeys are young, from three to six weeks old. Their presence shows that the farms from which these turkeys came were infected with gape worm embryos, which must have increased the death rate among the young turkeys grown there earlier in the season.

From visits made among turkey raisers in other sections of the State the past season, we learned that on many farms gape worms had caused the death of fifty per cent. of the little turkeys for many years, and in many cases those who suffered such losses, while they realized the cause, knew nothing that could be done to prevent or cure the trouble. Remedies that have been used with success were given in poultry books published more than fifty years ago, and measures may be carried out that will entirely rid a place of them in a few years. For the life history of the gape worm, with illustrations and directions for preventing and stamping it out, compiled from best sources, see Sixth Annual Report of the R. I. Agricultural Experiment Station, page 295.

OTHER PARASITES OF TURKEYS.

Ailing turkeys that were free from either "black head" disease, tape worms or gape worms, were found to be infested with ticks and lice. The ticks, several in number, were usually fastened to their head or neck. Round worms were occasionally found in the intestines; usually no more than a single pair were found in one bird.

RHODE ISLAND POULTRY ASSOCIATION.

In previous reports we have commented upon the R. I. Poultry Association, the value of its annual exhibitions to the poultry industry of the State, and on the desirability of maintaining, in connection with the exhibitions, features of more direct benefit to practical poultrymen and farmers.

As a member of the society we have endeavored to accomplish as much as possible in this direction, also, while serving the society as Secretary during the last two years. Larger and more varied prizes have been offered on dressed poultry and on turkeys and geese. New classes have also been made for cross-bred fowls, turkeys and geese. As a result, the dressed poultry exhibit at the last two exhibitions has excelled that of any other poultry exhibition held in this country, while the show of turkeys and geese has become quite an important attraction. This progress in making the exhibition of greater public value is gratifying, but we feel that it has been very slight compared with what may be done in a few years if practical poultrymen will take a more active interest in this department of the show and push it along. With the exception of the last few years local fanciers have furnished the funds required to meet the expenses of the shows, while the whole State has received the benefit. When the poultry shows became an old story to amusement seekers, and door receipts could not be depended upon to offset expenses, the members of the society were obliged to go deeper into their pockets each year to maintain the annual exhibitions, and finally this became a heavy burden on comparatively a few, who, feeling reluctant to see the shows given up, applied for State aid, and secured for the society an annual appropriation of $300 to pay premiums, which was increased a few years later to $400. This grant insured an exhibition, but was not sufficient to enable it to pay all expenses, and fanciers have continued to contribute funds each year rather than not hold a creditable show. Of late practical men interested in the dressed poultry feature, and others besides fanciers, have become members and have helped support the exhibition. The State Board of Agriculture has also aided the association by holding, during one or two days of the show, a poultry institute. The addresses, delivered by several of the most prominent raisers of poultry and geese, as well as discussions which followed, are published in the Annual Report of the State Board of Agriculture.

We hope to see represented in the dressed poultry classes of our Annual State Poultry Shows of the future all the varieties of pure bred fowls that are suitable for table purposes. May the time soon come when breeders will be as particular to show both dressed specimens and eggs of their favorite breeds as to exhibit them alive. When such a custom prevails a great improvement in the table qualities of all the large breeds will at once take place. Fanciers can improve in one direction as well as in another; they can select and mate to produce flesh or larger eggs as well as beautiful plumage.

A TABLE POULTRY SHOW IN ENGLAND.

In France and England dressed poultry shows are regularly held. From Dec. 11th to 13th, 1894, a show of dressed poultry exclusively was held in Royal Agricultural Hall, London. The objects of the exhibition, as stated by the prize list, were to encourage the production of an increased supply of table poultry, to encourage improvement in breeds of table poultry and in methods of feeding and fattening, and to give practical instruction in the best methods of dressing and preparing poultry for market and table use. Prizes were offered on various cross-breds and pure breeds of fowls, and on capons, ducks, turkeys, geese, guinea fowls and rabbits. Specimens were required to be sent killed and plucked (except on head and neck), but were not allowed to be drawn or scalded or to have the breast bones broken or heads, combs or feet cut off or scalded. The corporation of the City of London offered as prizes silver cups valued at $50;

$805 was offered in premiums. Two judges were employed, and were instructed to regard quality of flesh and smallness of bone and offal as of primary importance, although size was to receive its proper consideration. The prize-winning poultry were sold at auction on the second day. It will be seen that England is not slow in these matters. Canada is also alive and making great strides in the development of her poultry industry.

The R. I. Poultry Association aims to have an exhibit of the different varieties of the choicest pure bred poultry, the latest appliances used in poultry culture, and to make the dressed poultry feature of more and more value each year. It has broadened its field and increased its usefulness, and has good ground for receiving a much larger appropriation from the State. The expense of running a poultry exhibition in a large city each winter is quite considerable, but the advantages thus afforded the people of the State are proportionately great. The progressive State Poultry Associations of Minnesota and Nebraska receive $1,000 annually from their State Legislature. We hope that our own State Association will soon receive a like sum.

Doubtless it would be of great advantage to the society, as well as the State, if its shows were held in different towns or cities. If a large exhibition was held in Providence only every fifth year, and smaller ones at either Westerly, Newport, Woonsocket, Pawtucket or East Greenwich the other years an interest would be created in each locality, and a membership probably secured that would enable the society to be more fully represented throughout the State.

While the Experiment Station Board of Managers has allowed us to take whatever time has been necessary to carry out the duties of Secretary of the R. I. Poultry Association for the past two years, the amount required has been so great that it has somewhat interfered with our regular Experiment Station work; therefore it is not probable that we will again be able to take as active a part in the affairs of the Society.

CROSS BREEDING OF FOWLS.

Experiments in crossing fowls for the production of table poultry were continued the past season. Aseels were crossed with White Wyandottes and Pea Comb Plymouth Rocks; Indian Game with Langshans; Houdan with Langshans and Indian Games; White Game with White Brahmas and White Plymouth Rocks, and White Indian Game with Pea Comb Plymouth Rocks. Neither the White Indian Game, White Game nor Aseel were found to be as satisfactory for the production of table poultry as the dark Indian Game. Aseels were found to be unsuited for use in the practical production of table poultry. None of the crosses mentioned were equal to the crosses recommended in the Fifth Annual Report for the season of 1892.

The conclusions drawn from the three years' experiments in crossing fowls, and the details of the experiments of the last two seasons, will be presented in some future publication.

EXPERIMENTS WITH GEESE.

The results of the second season's experiments in crossing geese have been quite satisfactory. Various breeds and crosses have been raised and compared with each other as to growth and quality. Pure Black African, Embden and Toulouse geese have been grown, as well as crosses from Embden and Toulouse, Toulouse and Embden, Embden and Black African, Black African and Toulouse, and Wild Canada and Black African or India. The goslings were hatched on or within a day or two of April 30th, were fed and pastured alike, and the weights of each kind and cross were recorded at regular intervals. According to the results the Black African is the best pure breed for profitable production, while the Embden, as regards early growth and quality when dressed, is more desirable that the Toulouse variety. First crosses from the best breeds gave better results than the pure breeds. These young geese, both crosses and pure breeds, were exhibited at the Kingston and State Fairs, and at the Exhibition of the R. I. Poultry Association. At the latter exhibition the different crosses were shown both alive and dressed.

Probably this Division will devote its energies the coming season to the study of goose culture. More extensive experiments in crossing geese have been planned and the necessary stock procured. The various pure breeds will be compared as to egg production, and the artificial incubation of geese eggs will also receive considerable attention. The details of these experiments, with illustrations of the breeds used and their various crosses, will be given in a future bulletin.

The correspondence of this Division has increased considerably during the past year. All letters asking for information relating to poultry matters received from citizens of this State, and a good number from those of other States, have received careful attention.

METEOROLOGICAL REPORT.

NATHANIEL HELME.

Summary for 1894.

Maximum temperature	93°	June 17th, July 29th.
Minimum temperature	9°	February.
Range of temperature for the year	102°	
Mean temperature	48.6°	
Highest monthly mean	72.1°	July.
Lowest monthly mean	24.9°	February.
Highest daily mean	78°	June 23rd.
Lowest daily mean	1°	below zero Feb. 24th.

Precipitation.

Total (rain and melted snow) for the year	48.19	inches.	
Largest total for one month	9.14	"	October.
Least total for one month	.50	"	June.
Total snow fall for the year	75½	"	
Largest amount of snow in one month	24½	"	January.
Least amount of snow in one month	4	"	March.

Weather.

Number of clear days in the year	110
Number of fair days in the year	130
Number of cloudy days in the year	125
Number of days with precipitation of .01 inch or more	114

Air Pressure in Inches.

(Not reduced to sea level and temperature of 32°).

Maximum pressure	30.54	February
Minimum pressure	28.55	January.
Mean pressure	29.85	

January was warmer than the same month in the two years preceding, and the precipitation was slightly more than that of 1893, but less than that of 1892. The snow fall was 24½ inches. At the close of the month the average depth of snow on the ground was 14 inches.

February was stormy and very cold. Gales were very frequent. Travel was considerably impeded by the drifting of snow in the highways. The precipitation was little more than half of that of February, 1893. The snow fall was 24 inches, and the average depth of snow on the ground at the end of the month was 10 inches. The lowest temperature recorded during the month was also the lowest of which we have record here for the last thirteen years.

March was quite mild on the whole. The ground was bare of snow the greater part of the month. All that fell disappeared very soon afterward. The rain fall was about one-third that of March, 1893. There was no frost in the ground at the end of the month, and at that time grass had started considerably, giving a green appearance to the fields.

The mean temperature of *April* was about the average. On the 11th and 12th occurred a severe storm which did much damage along the coast. The last part of the month was quite warm.

May opened warm, the highest temperature, 87°, being recorded on the 2nd. The coldest weather occurred in the middle of the month. On the 15th there was a killing frost in low and exposed places. The mean temperature was a little above the average.

June was very hot and also very dry. The rain fall, one-half an inch, was the least that has been recorded in any one month during the seven years in which a record has been kept here.

July and *August* were also very dry months. Crops suffered considerably for lack of moisture. Wells and streams ran very low, cisterns became entirely dry, and many people were obliged to go quite a distance to obtain water. The total rain fall for the three summer months was less than half of that for the same time in 1893, and for the eight months ending with August the total precipitation was seventeen inches less than for the first eight months of 1893.

September temperature was slightly above the average, and the rain fall was very nearly the average for the month in former years. The weather was generally favorable for harvesting.

October, *November* and *December* show an increase in precipitation, that of October being three times as much as in 1893, and six times as much as in 1892. November shows a decided increase over that of the same month in 1893, and December but a slight increase. Six and one-half inches of snow fell in November, and five and one-half in December. The total precipitation for these three months was five-twelfths of the total for the year.

The last spring frost came June 14th, and the first fall frost formed August 22nd. The last snow of the winter fell April 12th, and the first in the autumn came November 5th.

METEOROLOGICAL SUMMARY.

	JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.	
	1894.	1893.	1894.	1893.	1894.	1893.	1894.	1893.	1894.	1893.	1894.	1893.
Temperature.												
Maximum	52.°	50.°	47.°	48.°	60.°	54.°	74.°	64.°	87.°	82.°	93.°	92.°
Minimum	4.°	—6.°	—9.°	—1.°	14.°	8.°	18.°	23.°	35.°	36.°	42.°	46.°
Mean	29.5°	19.4°	24.9°	26.9°	40.°	32.2°	44.5°	42.8°	56.1°	54.8°	66.2°	63.5°
Air pressure in inches.												
Maximum	30.85	30.46	30.54	30.48	30.29	30.53	30.24	30.40	30.22	30.12	30.08	30.13
Minimum	28.55	29.15	28.96	28.74	29.35	29.08	29.50	29.35	29.36	29.20	29.45	29.50
Mean	29.86	29.86	29.90	29.90	29.89	29.74	29.83	29.87	29.78	29.72	29.80	29.85
Precipitation in inches.												
Rain and melted snow	4.68	2.86	4.95	4.97	1.98	6.37	4.07	5.98	4.00	6.12	.50	3.92
Snow fall	24½	19	24	20	4	9	11	7	......	......	......	......
Weather.												
No. of clear days	9	9	7	10	8	11	9	9	10	12	5	6
No. of fair days	9	15	10	12	14	11	7	8	11	6	11	11
No. of cloudy days	13	7	11	6	9	9	14	13	10	13	14	13
No. of days with .01 inch or more precipitation	11	9	11	7	8	12	10	12	11	11	7	9
Prevailing wind	S.W.	S.W.	W.	S.W.	W.	W.	S.W.	S.W.	E.	S.W.	S.W.	E.

METEOROLOGICAL SUMMARY.—CONTINUED.

	JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	1894.	1893.	1894.	1893.	1894.	1893.	1894.	1893.	1894.	1893.	1894.	1893.
Temperature												
Maximum	93.°	91.°	85.°	87.°	85.°	76.°	70.°	72.°	63.°	67.°	55.°	58.°
Minimum	49.°	48.°	42.°	48.°	39.°	40.°	32.°	27.°	11.°	15.°	6.°	0.°
Mean	72.1°	69.°	65.°	68.8°	64.5°	58.3°	52.5°	53.2°	36.9°	40.1°	31.4°	31.°
Air pressure in inches												
Maximum	30.18	30.02	30.02	30.05	30.37	30.20	30.20	30.37	30.40	30.40	30.30	30.52
Minimum	29.64	29.45	29.62	29.40	29.58	29.48	29.08	29.40	29.41	29.45	29.28	29.38
Mean	29.83	29.78	29.85	29.82	29.98	29.84	29.77	29.92	29.83	29.89	29.89	29.87
Precipitation in inches.												
Rain and melted snow	1.85	.95	2.74	5.84	3.96	3.76	9.14	3.02	5.26	3.87	5.66	5.52
Snow fall	......	......	......	......	......	......	......	......	6½	......	5½	17½
Weather.												
No. of clear days	10	14	10	12	7	12	11	11	13	9	11	10
No. of fair days	15	12	10	10	11	12	11	14	8	15	13	13
No. of cloudy days	6	5	11	9	12	6	9	6	9	6	7	8
No. of days with .01 inch or more precipitation	5	9	8	12	8	10	11	6	12	10	12	16
Prevailing wind	S.W.	W.	W.	N.W.	S.W.	W.	S.W.	W.	W.	W.	W.	S.W.

EXCHANGES AND DONATIONS.

Copies of the following Agricultural and other papers have been regularly received at this office, where they are kept on file for reference:

The Baltimore Sun, Md.
Mirror & Farmer, Manchester, N. H.
The National Provisioner, New York, N. Y.
The Holstein Friesian Register, Boston, Mass.
The Toledo News, Toledo, Ohio.
The Industrial American, Lexington, Ky.
The Practical Farmer, Philadelphia, Pa.
The American Agriculturist, New York, N. Y.
The Louisiana Planter, New Orleans, La.
The Southern Cultivator and Dixie Farmer, Atlanta, Ga.
Home and Farm, Louisville, Ky.
The Sugar Beet, Philadelphia, Pa.
The Pomona Herald, Providence, R. I.
Sentinel Advertiser, Hope Valley, R. I.
The New Dairy, New York, N. Y.
The University Record, Ann Arbor, Mich.
The Naturalist's Leisure Hour, Philadelphia, Pa.
The Agricultural Epitomist, Indianapolis, Ind.
The American Cultivator, Boston, Mass.
The American Horse Breeder, Boston and New York.
Western Farmer and Stockman, Sioux City, Iowa.
The American Grange Bulletin and Scientific Farmer, Cincinnati, Ohio.

Hoard's Dairyman, Fort Atkinson, Wisconsin.
Farm, Field and Fireside, Chicago, Ill.
Grange Visitor, Lansing, Mich.
The Village Record, West Chester, Pa.
The Elgin Dairy Report, Elgin, Ill.
Hope Valley Free Press, Hope Valley, R. I.
The Farmers' Advocate, Burlington, Vt.
The Connecticut Farmer, Hartford, Conn.
The Dorset Quarterly, Washington, Pa.
Wallace's Farm and Dairy, Ames, Iowa.
American Fancier, Johnstown, N. Y.
Ohio Poultry Journal, Dayton, Ohio.
California Cultivator, Los Angeles, Cal.
American Poultry Journal, Chicago, Ill.
N. E. Fancier, Danielsonville, Conn.
Midland Poultry Journal, Kansas City, Mo.
Poultry Inter-Ocean, Decatur, Ill.
Poultry Monthly, Albany, N. Y.
The Fancier's Review, Chatham, N. Y.
American Stock Keeper, Boston, Mass.
Poultry Keeper, Parksburg, Pa.
Farm Poultry, Boston, Mass.
Southern Fancier, Atlanta, Ga.

Numerous reports and publications of the U. S. Government Department of Agriculture and other departments have been received, as well as all bulletins and reports from all the Experiment Stations in the United States, and some from Canada and New South Wales.

THE FOLLOWING BOOKS HAVE BEEN RECEIVED.

Holstein Friesian Herd Book, Vol. XI, Thos. B. Wales, Sec., Boston, Mass.

Ohio Poland China Record, Vol. XVI, Carl Friegan, Sec., Dayton, Ohio.

Ayrshire Record, Vol. II, Henry E. Smith, Enfield, R. I.

American Dairying—Gurler, J. H. Sanders Pub. Co., Chicago, Ill.

Our Farming—Terry, The Farmer Co., Philadelphia, Pa.

American Agriculturist, eighteen vols. O. A. Read, Providence, R. I.

Report on Injurious and other Insects of New York, 1891-'92, Dr. Lintner.

Injurious Insects and the Use of Insecticides, W. Atlee Burpee.

Agriculture of Massachusetts, Index, 1837–1892, Mass. State Bd. of Agr.

State Horticultural Society of Missouri, 36th Annual Report, L. A. Goodman, Sec.

Biennial Report Kansas Horticultural Society, 1891–1893, G. C. Brackett, Sec.

Missouri Botanical Garden, Fifth Annual Report, Wm. Trelease, Dir.

Florida State Horticultural Society, Proceedings Sixth Annual Meeting, L. B. Wombwell, Commissioner of Agriculture, State of Fla.

California State Board of Horticulture, Bulletins 63–67.

Transactions of the Mass. Horticultural Society for 1894, Part I, Robert Manning, Sec.

Transactions of the Worcester Horticultural Society, 1892 and 1893. A. A. Hixon, Lib.

Report of Fruit and Vine Growers of New South Wales, 1890, Dept. of Agr., New South Wales.

Agricultural Gazette of New South Wales, Dept. of Agr., New South Wales.

Farm Statistics of Michigan, 1892–1893, J. W. Jochim, Sec. State.

Proceedings Ayrshire Breeders Association, 19th Annual Meeting, C. M. Winslow, Sec.

Die Kalidüngung, by M. Maercker, German Kali Works.

Report of R. R. Commissioner, Rhode Island, 1894, E. L. Freeman.

Report of State Board of Agriculture of Virginia, 1894.

Midwinter Bulletin No. 2, Maine State Board of Agriculture.

OTHER DONATIONS.

One Breed's Weeder, Zephaniah Breed Weeder Co., Boston, Mass.

One Comet Bug Killer, Lucien Sanderson, New Haven, Conn.

Samples of crude and commercial nitrate of soda from World's Fair Exhibit., S. M. Harris, Moreton Farm, Monroe County, N. Y.

One bag (200 lbs.) muriate of potash and one bag (200 lbs.) sulphate of potash, German Kali Works, New York, N. Y.

Trio of Blue Turkeys from Virginia, Dr. O. C. Wiggin.

REPORT OF THE TREASURER.

MELVILLE BULL.

THE RHODE ISLAND AGRICULTURAL EXPERIMENT STATION *in account with the* UNITED STATES APPROPRIATION.

1894.	DR.		
	To receipts from the Treasurer of the United States as per appropriation for the year ending June 30, 1894, under act of Congress approved March 2, 1887		$15,000 00
1894.	CR.		
June 30.	By Salaries	$8,707 06	
	Labor	2,305 33	
	Supplies and repairs	1,200 00	
	Freight, expressage, etc	429 47	
	Library and printing	849 41	
	Tools and Machinery	382 31	
	Scientific instruments	90 06	
	Chemical apparatus and supplies	125 64	
	Furniture and general fittings	29 12	
	Live stock	323 19	
	Traveling	281 25	
	Incidentals	99 58	
	Building	177 58	
			$15,000 00

THIS CERTIFIES THAT WE, the undersigned, authorized Auditing Committee of the Board of Managers of the Rhode Island College of Agriculture and Mechanic Arts, have examined the accounts of the Treasurer of the Agricultural Experiment Station for the fiscal year ending June 30, 1894, and that we find the receipts for the time named to have been $15,000, and that the same has been expended, for which satisfactory vouchers, correctly classified as above, are on file, and the same agree with the Treasurer's account, and there is no unexpended balance.

GARDINER C. SIMS,
NATHAN D. PIERCE,
CHAS. J. GREENE,
Auditing Committee.

I hereby certify that the above is a true copy from the books of account of the institution named.

MELVILLE BULL,
Treasurer of the Rhode Island College of Agriculture and Mechanic Arts.

I hereby certify that the above signature is that of the Treasurer of the Rhode Island College of Agriculture and Mechanic Arts.

C. H. COGGESHALL,
President of the Board of Managers of the Rhode Island College of Agriculture and Mechanic Arts.

MELVILLE BULL, *Treasurer, in account with the* RHODE ISLAND AGRICULTURAL EXPERIMENT STATION.

1894.	DR.	
June 30.	To balance from last year	$8 59
	Rebate on Columbian Fair freight	4 97
	Station receipts	1,369 00
	State receipts, Fertilizer inspection	1,666 38
	Interest	53 78
		$3,102 72
	CR.	
	By Labor	$709 43
	Supplies and repairs	1,948 90
	Roads, water supply, etc	49 90
	Fertilizer inspection	309 11
	Incidentals	50 10
	Balance on hand	35 28
		$3,102 72

Melville Bull, *Treasurer, in account with* United States Special Appropriation.

1894.	Dr.	
June 30.	To balance on hand	$1,639 07
	Interest	105 18
		$1,744 25

1894.	Cr.	
June 30.	By Library and printing	$159 78
	Scientific instruments	2 50
	Balance unexpended	1,581 97
		$1,744 25

This is to Certify that the undersigned, Auditing Committee of the Board of Managers of the Rhode Island College of Agriculture and Mechanic Arts, have examined the accounts of Melville Bull, Treasurer, ending June 30, 1894, and the vouchers corresponding therewith, and find the same correct.

GARDINER C. SIMS,
NATHAN D. PIERCE,
CHAS. J. GREENE,
Auditing Committee.

BULLETINS

AND

ANNUAL REPORT

OF THE

RHODE ISLAND

Agricultural Experiment Station,

FOR THE

YEAR 1894.

PROVIDENCE:
E. L. FREEMAN & SON, PRINTERS TO THE STATE.
1895.

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ERRATA.

Page 199, third line from the bottom, for favorably read *favorable.*

" 240, ninth line from the top, for moses read *mosses.*

" 242, eighth line from the top, for carbonate read *carbonated.*

" 253, first line, for Prittany read *Brittany.*

" 264, in heading of right-hand column of table, for air-dried read *dried.*

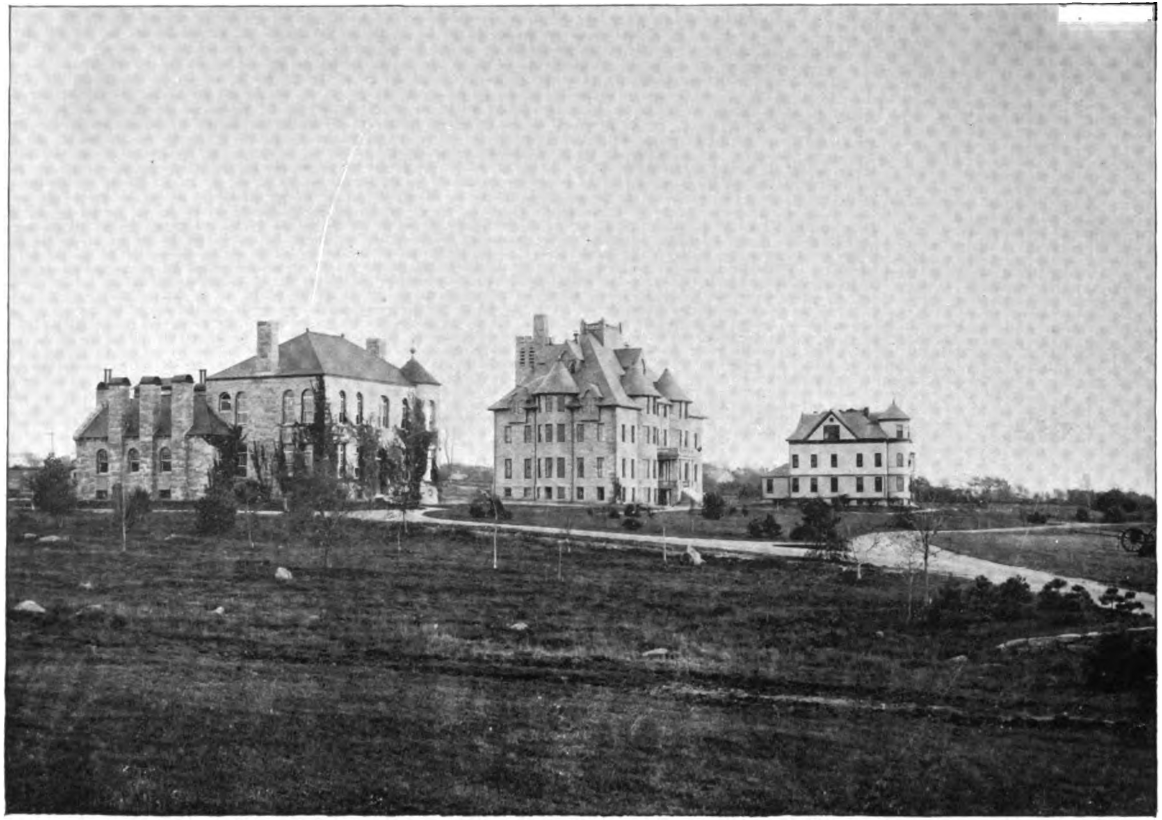
" 268, plate following, in Figs. 4 and 5, for Plot 6 read *Plot 1*; for Plot 5 read *Plot 2*; for Plot 4 read *Plot 3*; for Plot 3 read *Plot 4*; for Plot 2 read *Plot 5*; for Plot 1 read *Plot 6.*

" 269, omit lbs. in the two right-hand columns of table.

" 271, fifth and eighth lines from the top, for then read *than.*

" 307, Thermometer No. 2, under 1½ in. Wrought Iron Pipes, in column 2.15 P.M., for 56° read *59°.*

UNIV. OF MICH.



CHEMICAL LABORATORY. COLLEGE HALL. BOARDING HALL.

State of Rhode Island and Providence Plantations.

EIGHTH ANNUAL REPORT

OF THE

RHODE ISLAND AGRICULTURAL EXPERIMENT STATION, Kingsto

1895.

PART II.

OF THE

EIGHTH ANNUAL REPORT

OF THE

CORPORATION, BOARD OF MANAGERS,

OF THE

Rhode Island College of Agriculture and Mechanic Arts,

MADE TO THE

GENERAL ASSEMBLY AT ITS JANUARY SESSION, 1896.

[PART I. OF THIS REPORT — COLLEGE CATALOGUE — IS PRINTED UNDER SEPARATE COVER].

PROVIDENCE, R. I.
E. L. FREEMAN & SONS, PRINTERS TO THE STATE.
1896.

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The publications of the station will be mailed free "to such individuals actually engaged in farming as may request the same." The station desires the co-operation of the farmers of the State in the work of investigation, and any facts concerning unusual animal or vegetable growth or disease, are solicited. Visitors are always welcome. Railroad station, telegraph, express and post office—Kingston, Rhode Island.

LETTER OF TRANSMITTAL.

To His Excellency Charles Warren Lippitt, Governor, and the Honorable the General Assembly of the State of Rhode Island, at its January Session, 1896:

KINGSTON, JANUARY 31ST.

I have the pleasure to present herewith, in compliance with the statute of the State and the Congressional act of March 2, 1887, the Report of the Director of the Rhode Island Experiment Station to John H. Washburn, President of the College, together with that portion of the Report of Hon. Melville Bull, Treasurer of the Board of Managers of the Rhode Island College of Agriculture and Mechanic Arts which relates exclusively to the Experiment Station.

Respectfully submitted,

For the Board of Managers,

C. H. COGGESHALL,

President.

REPORT OF DIRECTOR.

CHAS. O. FLAGG.

To J. H. Washburn, President:

There are few changes to note in the personnel of the Experiment Station Staff in the year now drawn to a close. At the beginning of the year Miss A. R. French, who since the organization of the Station had discharged the duties of clerk with ability and satisfaction, retired from the position. The rapidly increasing volume of correspondence, and the consequent demands upon the time of Station workers, made the services of a stenographer highly desirable, and Miss B. E. Bentley was employed in that capacity. A room formerly occupied by the Director has been fitted up with cases for the convenient keeping of surplus copies of our reports and bulletins and for preparing them for mailing. The mailing list for the State has been printed, and a "Dick Mailing Machine" purchased, so that the labor of addressing envelopes and mailing bulletins is materially reduced and more time afforded for the proper keeping of records, care of library, and other duties. The work of rebuilding College Hall, destroyed by fire on January 27th, led to the transfer of Mr. H. F. Adams from his duties as farmer to the charge of teams and labor connected with the construction of the new dormitory. The oversight of farm operations since that time has devolved upon the Assistant Agriculturist, Mr. Geo. M. Tucker. Mr. Geo. E. Adams, who since his graduation in '94 has been employed in the work of the Horticultural Division was, early in the year, appointed to the position of Assistant Horticulturist, and the seed investigation placed under his immediate charge. The duties of other members of the Station Staff have remained the same as heretofore.

PUBLICATIONS.

While the very best way in which to become familiar with the work of the Station is through a personal visit during the summer, and while visitors are always welcome (Sundays excepted), there are many so situated that they find it impossible to accept the standing invitation to visit the Station. To such the bulletins and reports, with occasional correspondence, must form the medium of their knowledge of the experimental work conducted here. Our publications are sent free within the State "to such individuals actually engaged in farming as may request the same," and addresses so received are entered upon our mailing list. We strive to keep the list corrected up to date and any person whose name is on our list and who changes his residence for any reason and still wishes to receive our publications should notify us of the change in address, otherwise bulletins sent out will be returned to us and the name will be stricken from our list. We desire to be informed of any failure to receive our publications when no change of address has been made, and will endeavor to learn the cause of such failure. We are pleased to note an increase in the number of applications received, believing it to be an indication that farmers are studying the principles involved in their business, thinking more and seeking information that may help them to attain a greater measure of success.

There have been printed and issued during the year the following publications:

Annual Report 1894, pp. 87–224. Cuts, 56.

Bulletin No. 31. April. Some Special Orchard Treatment of the Apple, Pear and Quince. pp. 1–18. Cuts, 9.

Bulletin No. 32. June. Analyses of Commercial Fertilizers. pp. 19–30.

Bulletin No. 33. October. Fertilizers. Potatoes. Potato Scab. pp. 31–80. Cuts, 6.

Bulletin No. 34. December. Analyses of Fertilizers. Home-Mixed Fertilizers. pp. 81-128. Cuts, 3.

Bulletin No. 35. December. Garden Seeds. pp. 129–168. Cuts, 6.

THE SEASON.

Heat and water as embodied in sunshine and rain are highly essential elements in the production of all agricultural crops. The farmer may prepare his ground wisely, invest money in fertilizers and seed, plant the same to the best advantage in the soil and keep the weeds in thorough subjection, yet if the supply of heat and water be either scanty or excessive his efforts and outlay will prove in great measure a failure. The hilly and naturally well-drained soil of New England is far less likely to suffer from excessive rains than the lower level lands of the west and lands bordering great rivers. A lack of sufficient moisture usually accompanied by excessive heat during a period when vegetation should be making a most rapid growth is the greatest menace to successful agriculture, and wherever drought decreases the crops the importance of placing within reach of the plant at all times a sufficient supply of moisture is being more and more recognized by thinking men as of first importance in crop production. How this can be most economically attained is a question of general interest and widespread investigation. Deep and thorough surface plowing, subsoil plowing, frequent and shallow cultivation, for the purpose of maintaining on the surface a *mulch* of fine dry earth to prevent loss of moisture by evaporation, and irrigation are all phases of this important question.

The mean average temperature for the past six years as taken by the Meteorologist is 48.1°, and the mean temperature for 1895 was 48.2°. The average annual precipitation, rain and melted snow, during the same period has been 51.08 inches, and the total precipitation for 1895 was 49.28 inches, which, taken together with the amount of sunshine as shown by the table of clear, fair and cloudy days, shows the past year to have been on the whole favorable for crops and agricultural operations.

	1895.	1894.	1893.	1892.	1891.	1890.
Clear days..............	128	110	126	147	116	99
Fair days..	114	130	130	116	154	143
Cloudy days.............	123	125	109	103	95	123
Rainy days...............	108	114	131	89	83	120
Total of rain and melted snow—inches	49.28	48.19	57.33	42.58	49.88	59.25
Mean temperature........	48.2°	48.6°	46.5°	47.8°	49.4°	48.3°

The rainfall was far more equally distributed in 1895 than during the previous year when a drought prevailed in June and July, only 1.85 inches of rain falling as against 9.19 in the same months in 1895. So plentiful a supply of moisture during these two months proved very beneficial to most crops, but doubtless was accountable, in some measure at least, for the general prevalence of the potato blight. The last spring frost came May 19th, and about three months later, August 22d, the first autumn frost in low lands, but the first killing frost did not appear until September 15th. In 1894 the last spring frost was on June 14th, while the first autumn frost came on the same date as in 1895.

FERTILIZER INSPECTION.

The amount of work involved in the conscientious enforcement of the State Fertilizer Inspection Act increases from year to year through the organization of new companies and the sale of new brands within the State. In 1895 one hundred and twenty-five samples of fertilizers, agricultural chemicals and fertilizing materials were collected from dealers, agents, and farmers, analyzed and the results published as provided by law. Of that number one hundred and one were complete fertilizers, i. e., contained nitrogen, potash and phosphoric acid. This number exceeded that of 1894 by twenty brands, an increase of twenty-five per cent. Bulletins Nos. 32, 33 and 34 contain the analyses. The last named number gives the following percentage relation between the fertilizing constituents found and guaranteed, for the years 1891 to 1895 inclusive:

	1895.	1894.	1893.	1892.	1891.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Equal to or above the guaranty.....	88.97	80.89	75.74	80.71	71.06
Less than .3 per cent. below the guaranty....................	4.99	7.97	13.77	9.00	10.64
More than .3 per cent. below the guaranty....................	6.04	11.14	10.49	10.29	18.30

CHEMICAL DIVISION.

In addition to the work required by the State Fertilizer Inspection Act, for the payment of which with expenses incurred the license fees (collected by the General Treasurer) are appropriated, the Chemical Division has analyzed the fertilizing materials and chemicals used in the field and pot experiments and made numerous dry matter and chemical tests of experimental crops. Samples of water and fertilizing materials have been received from citizens in various parts of the State, and as far as the other work of the Station would allow and the results promised to be of interest and value to the public, analyses have been made and results reported to those who have forwarded the materials. Such analyses are now published and may be found in the report of the Chemical Division. In connection with the Agricultural Division, a number of field and pot experiments have been conducted, and others continued with such modifications in crops and treatment as experience has shown desirable. The results thus far attained appear to have an important bearing upon the question of proper fertilization and economical crop production. The report of the Chemical Division includes a report of progress along the lines of work under investigation.

Dr. Wheeler as Reporter on Potash to the Association of Official Agricultural Chemists has planned a comparative test of the two official methods of potash determination, and has tabulated and prepared for publication the results secured at this and other Experiment Stations. The work has an important bearing wherever fertilizer analyses are made.

FIELD AND POT EXPERIMENTS.

The field experiments have been confined almost wholly to the plain land and are largely a continuation of work already undertaken. The following experiments are being conducted jointly by the Agricultural and Chemical Divisions:

A continuation of the observations upon the growth of plants upon an acid soil before and after liming. A study of the peculiarities of grasses has been made the special feature in this connection.

The soil test with plants has been continued for the purpose of further testing in how far the results secured by soil tests with a given plant are applicable to plants in general.

A continuation of the experiments on the substitution of soda for, and its value in connection with, potash.

A continuation of the observations on the comparative efficiency of different forms of nitrogen when used with and without lime.

Observations upon the effect of ammonium sulphate, sodium nitrate, sodium carbonate, common salt, oxalic acid, barnyard manure, and various compounds of lime upon the development of the potato scab.

Observations upon the action of various alkalies upon the growth of plants upon an acid soil.

A test of the comparative efficiency of equal quantities of lime in the form of air-slacked lime and of land plaster (gypsum) in promoting the growth of beets upon an acid soil.

AGRICULTURAL DIVISION.

Six rotations occupying 28 one-tenth acre plots have been continued with fair results wherever lime has been applied. Grass and clover seed fails to make anything like a satisfactory growth and often fails entirely to "catch" without the application of air-slacked lime. No difficulty has yet been experienced in securing a "catch" of grass seed after liming the land.

The phosphate experiment has been continued, using oats instead of corn as a crop. The rapid growth in the early spring, and dark color of the foliage on the limed plots was quite noticeable with nearly all the plots. Two more plots were added to the series[1] making 20 in all for the purpose of testing "Double Superphosphate" in comparison with other materials as a source of phosphoric acid. This fertilizer is a very concentrated source of available phosphoric acid, as a sample of that used in the experiment analyzed 27.35 per cent. soluble, and 17.29 per cent. reverted, or a total of 44.64 per cent. of available phosphoric acid.

The oats grew so rapidly and vigorously on the limed plots that they were badly lodged by a severe storm about the time of blossoming, and consequently the heads filled very unevenly. The plots used in this experiment were seeded to grass and clover after the removal of the oat crop and at the beginning of winter the young grass upon the different plots presented very little difference in appearance, although the growth was small owing to dry weather after seeding.

The growth of leguminous plants without nitrogen and with varying amounts of nitrogen has been continued with the addition of field corn, spring rye, oats, barley and two varieties of millet.

Test of Fodder Plants. Egyptian Lentil, two varieties of cowpea, alfalfa and Leaming corn were grown aside from leguminous plants included in the previous experiment.

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[1] See Seventh Annual Report, p. 124.

Test of northern versus home grown seed potatoes was conducted with fourteen varieties.[1]

Test of budded versus dormant seed potatoes for the purpose of learning if budding hastens the maturity of the crop, and what effect it has upon the yield.[1]

Test of Jensen hot water treatment of oats for the prevention of smut. Thirteen varieties.

Field experiments with the use of lime in seeding to grass and clover.

HORTICULTURAL DIVISION.

Work in this Division may be briefly outlined as follows:

Experiment in greenhouse heating. A small greenhouse was provided with two sets of piping; one of four inch cast iron and the other of one and one-half inch wrought iron pipes. The result of this experiment is included in this report.

Seed testing. Two hundred and forty-six samples of vegetable and clover seeds were procured by purchase from various seedsmen and tested as to freedom from impurities and power of germination. The results of this work have already been published in Bulletin No. 35.

Remedies for the plum-rot. Mr. N. S. Allen of East Greenwich in 1894 had an exceptionally heavy crop of fruit upon his plum trees (estimated at 50 bushels) which, however, proved nearly a total loss through the prevalence of plum-rot. This orchard was kindly placed at the service of this Division for the season of 1895 for experimental preventative treatment. Seven different solutions were prepared and certain trees sprayed with them to prevent fungoid growths. Late frosts injured the fruit buds, and that, together with the excessive overbearing of the trees the previous year, caused an entire failure of the plum crop, so that no results were secured. Further work in this line is contemplated.

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[1] See bulletin No. 36. January, 1896.

Remedies for the canker worm. Three different materials were used as bands on the trunks of apple trees as a protection against the destructive work of the canker worm which was expected to make an appearance. As only occasional female moths were found, banding the trees gave no results as unprotected trees suffered no injury.

Small fruits. Plants of the Loganberry, Golden Mayberry, "Strawberry-Raspberry," Pearl Gooseberry, Lotta Black Cap, Margaret Strawberry, Columbia, Royal Church and Loudon Raspberries, Chautauqua Gooseberry, Eldorado Blackberry and Buffalo-berry, were set this year. The Japanese persimmon, Crosby peach, six varieties of Japanese plums and two new plums from the Pacific coast, beside apple scions and some other fruits, were set for trial.

Several new vegetables were grown but none proved superior to well known varieties.

Sulphate of copper solution was used as a remedy for leaf blight of celery and the Bordeaux mixture was successfully used in protecting potatoes from blight.

Some work was done in trying remedies for the anthracnose of the grape and to prevent the ravages of the rose bug in the vineyard.

The destruction of the pupæ of the apple maggot by confining poultry under the trees was tested, with what success can only be determined later.

The New "Model" fumigation apparatus was tried in greenhouse work.

Spring and fall sowings of crimson clover were made in the orchard.

POULTRY DIVISION.

The work outlined for the season of 1895 was the rearing of geese, both pure and cross-bred, for the purpose of comparison as to desirability for market, hardiness and profitable growth. Twenty matings were planned and the breeding stock for eighteen of them was kept on the farm. Considerable difficulty was experienced in securing suitable breeding stock so that some of the matings were not made up until too late in the winter for satisfactory results. The poultry grounds as originally established included an out cropping mass of granite rock which has since been worked for a supply of building stone. To secure the material for rebuilding the burned dormitory, quarrying operations began in early spring and the necessary drilling, blasting and other work seriously disturbed the seclusion and peaceful conditions recognized as conducive to success in goose raising. Owing to the above causes many eggs proved infertile and comparatively few goslings were raised. Work in the same line will be repeated, it is hoped with greater success. An exhibit of live geese was made at the Washington County Fair and a display of dressed geese at the Rhode Island Poultry Show.

BLACK-HEAD OF TURKEYS.

In the autumn Dr. V. A. Moore, Chief of the Bureau of Animal Pathology at Washington, visited the Station for a conference regarding the so-called " Blackhead " disease of turkeys (Infectious Entero-Hepatitis). Several infected farms were visited and plans formulated for experimental tests as to the direct transmission of the disease. Duplicate tests were to be made on the Station grounds and by the Division of Animal Pathology at Washington; the diseased turkeys for the latter to be sent on from this Station.

Yards have been constructed, turkeys secured and the experiment is now well initiated.[1]

APIARY

Eighteen colonies of bees came through the winter of 1894–95 in good condition and were handled during the season for honey production. Comparatively little surplus was however secured until late in the season when a fair amount was taken off. The quality was so dark and inferior however that most of the product will be used for feeding in the spring to stimulate brood rearing.

FARM CROPS.

In the fall of 1894 all the plowed farm lands at the easterly, or hill end of the farm, with the exception of about half an acre, were seeded to grass. A piece of rather more than four acres north of the orchard was seeded at that time and the autumn growth was fairly satisfactory. In the spring of 1895, however, the grass failed to start except in scattered clumps and more weeds than grass appeared later in the season. The crop was not worth cutting for hay, but the field was mown to prevent the weeds from ripening seeds. This field was plowed August 23rd to 30th and broadcasted with 1 ton of air-slacked lime per acre. On September 18th it was seeded to grass, using 12 qts. of Timothy, 6 lbs. of cleaned red top and 4 lbs. of alsike clover seed.

At the beginning of winter the seeding gave promise of a good catch and a profitable crop the coming year.

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[1] Circular Bulletin No. 5, issued by the U. S. Department of Agriculture, Bureau of Animal Industry, contains the results of the Washington experiment. The disease was produced in healthy turkeys by feeding them fæces from, or portions of, diseased birds. Hence, great care should be exercised by turkey raisers to feed flocks only upon ground uncontaminated by the droppings of diseased turkeys and to remove all affected turkeys from among healthy ones. Especial care should be taken to burn or bury deeply (first covering the carcass with quick-lime) any turkey which has died from this disease. Diseased turkeys in a flock may die in the fields and if not burned or buried may be eaten by other turkeys, thus creating wide-spread infection.

LIME AND TIMOTHY.

The field on the plain, west of the twentieth-acre plot experiment, on which clover seed failed to "catch" in 1893, and which was therefore plowed at midsummer and re-seeded in the fall of 1894 after receiving a top dressing upon the two acres of four and one-fifth tons of air-slacked lime, produced the finest crop of Timothy hay thus far grown upon the farm. The grass came up thick and uniform without admixture of weeds or foul growth of any kind and was of good color. A heavy rain storm the last of June laid down the grass upon a greater part of the field, most of which, however, straightened up sufficiently to make clean cutting with the mowing machine possible. Persons long familiar with the Station farm fail to recall ever having seen growing upon it so fine a field of grass. Seven good two-horse loads were taken from the two acres in the first crop. Timothy generally fails to give an aftermath sufficient in amount to pay for cutting, and the growth upon this field is interesting for the reason that the second growth was mainly upon the north half of the field which had received in 1892 a light dressing of air-slacked lime (1400 lbs. per acre). The application of air-slacked lime in 1894 was uniform over the field as was the application of fertilizers and cultural treatment, so that the excess of second crop on the north half of this field must apparently be attributed to the benefit arising from the extra appliation of air-slacked lime. It is well known that one effect of air-slacked lime upon light soils is to flocculate the finer particles, thereby improving its mechanical condition and making it more retentive of water. It hardly seems possible that the addition of so small a quantity of lime to the north half in excess of that applied to the south half could cause any well marked difference in the mechanical or physical conditions tending to change the per cent. of water in the soil upon the two sides of the field, yet the difference in the amount of second crop growth was very evident to even a casual observer. Little, if any, difference was noticed in the growth of the first crop upon the north and south sides.

LIME AND CLOVER.

A triangular piece of ground immediately west of the field of timothy and of the same width contains about three-fourths of an acre. Both lots were in one field in 1892 when air-slacked lime was applied at the rate of 1400 lbs. per acre on the north half of the field. No further application of lime has been made to the triangular piece. In that year the piece was sub-divided for the trial of various forms of phosphatic fertilizers[1], some of which, as slag meal, contained lime. In the spring of 1894 this piece was plowed and sown to oats and clover. In 1895 the growth of clover was very prominent upon the north side of the piece which received air-slacked lime in 1892 at the rate of 1400 lbs. per acre and only a little less marked upon a strip at the south side where the slag meal was used the same year in the phosphate experiment. A section of the piece south of that line and north of that to which slag meal was applied was very noticeable because of the almost entire absence of clover; only a few scattering plants appeared in the growth of sorrel which partially covered the ground. This piece was plowed September 13th and fertilized with one ton of air-slacked lime per acre. One and one-half bushels per acre of "Excelsior" winter rye was sown September 30th with 12 quarts of timothy, 6 pounds of cleaned red top and 12 pounds of red clover seed.

A field of four and a half acres[2] at the northwest corner of the plain, because of the failure of previous grass seeding to "catch," was plowed early in the spring of 1894, and sown to oats and clover. Before seeding, air-slacked lime at the rate of 1750 pounds per acre was thoroughly harrowed in and a home-mixed fertilizer made up as follows, was used broadcast: Nitrate of soda, 100 lbs.; tankage, 100 lbs.; dissolved South Carolina rock,[3] 200 lbs.; fine ground bone, 200 lbs., and muriate of potash, 200 lbs., making 800 lbs. of the mixture per acre. A rather severe drouth about the time the oats ripened and later threatened the existence of the young clover plants, but growth began with the coming of the autumn rains. The mowing machine with the cutter bar set well up from the ground was once run over it to clip off any tall growth of weeds or clover. The clippings were allowed to lie on the ground as a mulch, and the clover presented an even stand and thrifty appearance when the ground froze at the approach of winter. In the spring of 1895, the clover was found to have passed the winter in excellent condition and immediately started a very uniform growth. The first crop was cut June 20th, and was considerably damaged by subsequent wet weather. A cut from a photograph of the mowing machine at work in this field of clover is given in this connection, also an illustration of the second crop harvested August 16th. As no grass seed was sown with the clover this field was plowed September 5th to 11th, and seeded September 27th with 16 quarts of Timothy and 6 pounds of cleaned red top seed per acre. No additional application of lime was made, but a moderate dressing of fertilizer, compounded from various chemicals on hand at the end of the season's work was used, making a dressing equal to about 27 pounds of nitrogen, 74 pounds of potash, and 25 pounds of phosphoric acid per acre.

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[1] See Fifth Annual Report, p. 141.

[2] See Annual Report for 1894, p. 98.

[3] Called "Acid Phosphate," "Plain Superphosphate," or "Dissolved Phosphate Rock."

FIELD CORN.

South of the field just described is about eight acres of land which was seeded to grass in September, 1890, and has produced less than a ton of hay per acre the last two or more seasons. It was decided to plow the east half of this field and a strip parallel to the highway and containing just four acres was staked off. As the sod was very thin and the soil in an exceedingly poor condition, the following liberal quantity of fertilizer was applied per acre: nitrate soda, 225 lbs.; dissolved phosphate rock, 600 lbs.; fine ground bone, 105 lbs.; tankage, 200 lbs.; dissolved boneblack, 200 lbs.; muriate of potash, 150 lbs. The cost of these materials

CLOVER.

First Crop. Cut June 20th.

CLOVER.

Second Crop. Cut August 16th.

was $17.75 per acre, or $24 per ton. One-half of the above named quantity of fertilizer was applied broadcast upon the grass April 18th, for the purpose of stimulating a little growth before the sod should be turned under. May 16th the field was plowed, using a Sulky Swivel plow to avoid dead furrows, and immediately rolled to make the furrows lie as flat as possible. Air-slacked lime at the rate of 2300 pounds per acre was then applied broadcast with a "Spangler Lime Spreader," and thoroughly worked into the soil with a "Cutaway" harrow, after which the remaining half of the fertilizer was applied broadcast, the field again harrowed and bushed. The field was marked into checks—the rows one way being three feet apart, and three and a half feet apart the other way. A long, light pole to which six pound window weights were attached by wires at the desired distance apart, carried by two men, was used in marking, and with such an arrangement it can be rapidly done.[1] Corn of the Rhode Island White Cap (flint) variety was planted May 22, using hand automatic corn planters, and taking care to put the hills at the "checks" or intersections of the marks. June 8th the rows could be distinctly seen, and a "Breed's Weeder" was twice used to stir the soil and kill all weeds just germinating. Later an ordinary cultivator was used and a very little hand hoeing was found necessary to keep all weeds in subjection. Toward the latter part of June the corn presented a slightly yellowish appearance, and 100 pounds per acre of nitrate of soda was applied by scattering the salt in alternate spaces just before a rain. The following day the field was cultivated about two inches deep and but little more cultivating was found necessary. The corn quickly put on a dark, rich green appearance and grew rapidly. September 16th to 18th it was cut up at the ground and shocked in the usual manner, putting thirty-six hills in a shock. The corn was all husked in the field, weighed and put into cribs. The product of the four acres weighed: stover, 15,639 pounds, and sound corn 18,355 pounds; an average yield per acre of 3,909.75 pounds of stover, and 62.43 bushels of shelled corn; allowing 73.5 pounds of corn on the cob in October to make 56 pounds of shelled corn in February, as was determined by experiment.[1]

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[1] See Fourth Annual Report, R. I. Agr'l. Exp't. Sta., p. 82.

CROP HARVESTED.

The following figures include the yields from rotation and experimental plots as well as field crops: Corn, 650 baskets; rye, 70 bushels; oats, 45 bushels; potatoes, 140 bushels; roots, (carrots, beets and turnips,) 200 bushels; clover hay, 10 tons; Timothy hay, 6 tons; mixed hay, 6 tons; corn stover, 20 tons; rye straw, 3.5 tons; oat straw, 2.5 tons. Small quantities of various garden vegetables raised on experimental plots.

FARM STOCK.

The Experiment Station at present owns the following live stock not including poultry: one pair chestnut team horses, one pair grey horses, one chestnut driving horse, 3 Holstein cows, 1 Ayrshire cow, 1 grade Ayrshire cow, 1 grade Guernsey cow, 1 native cow, 1 two year old Ayrshire heifer, 1 yearling Ayrshire heifer, 1 yearling Ayrshire grade heifer, 1 three year old Ayrshire bull, 10 shoats.

Our stock of Berkshire hogs consisting of 1 boar, 2 sows and 12 pigs, all pure bred, and 15 grade Berkshire pigs, died from "Swine Plague" during July and August. All buildings, yards and pens have been thoroughly disinfected and no further outbreak is expected.

SEEDS FOR TRIAL.

In coöperation with the office of Experiment Stations at Washington, arrangements were made with a limited number of persons in the state to plant a few varieties of seeds furnished by the Seed Division of the U. S. Department of Agriculture and report later as to their value for cultivation in this section.

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[1] See "Indian Corn Experiments" in this report.

There were 586 packages of seeds representing 51 varieties of plants sent to 72 persons. Blanks for reports regarding the soil in which the seed was planted, the fertilizer used and the cultivation given, as well as the growth of the crops, total product and quality, were sent out in the fall. Reports were received from 29 persons and a summary of them shows that 29 of the 51 varieties are considered satisfactory as to the growth and quality of product; 17 varieties were unsatisfactory and 5 varieties either failed to germinate or to grow after germination.

A variety of yellow dent corn called "Extra Early Leaming" proved very productive on the Station farm, yielding at the rate of *115 7-10 bushels of shelled corn per acre.* Mr. Amos F. Maker of Warren reported a yield of 225 baskets of this variety per acre and others report the growth as very satisfactory. We shall endeavor another season to grow this variety of corn for comparison, under similar conditions, with the R. I. White Capped flint corn.

SEED TESTING.

At various times samples of seeds have been examined in reference to their freedom from weed seeds and foreign substances and tests made for the per cent. of vitality by germination, but not until this year has any definite work in this line been undertaken by this Station. Early in the spring of 1895 the Assistant Horticulturist collected by purchase from 19 seed dealers 233 samples of 13 kinds of common vegetable seeds. These were all carefully examined for impurities and germination tests made to determine the per cent. of vitality. The results of this work are already published[1]. In the samples of seeds collected very little foreign matter was found. If kinds having smaller seeds had been selected for investigation, a larger per cent. of impurity would doubtless have been obtained. Prof. Kinney says in his summary, "Many samples contained a large per cent. of dead seeds. In twenty of the samples three-fourths of the seeds were useless for planting purposes, and in twenty-three other samples one-half or more of the seeds failed to produce sprouts during the germination tests. On the other hand, in 64 samples only 5 per cent. or less of dead seed was found." It is evident that oftentimes the farmer and planter is subject to much annoyance and financial loss through the presence in the market of old and poor seeds and some more satisfactory guaranty of quality on the part of seed dealers is highly desirable and *we believe would prove profitable to the dealers.*

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[1] See Bulletin No. 35, December, 1895.

AGRICULTURAL FAIRS.

The hall exhibit made by the Station at the agricultural fairs was confined strictly to illustration by diagrams and photographs of the results of experiments and the work in seed testing. Several pens of breeding geese were shown at the Washington County Fair and some dressed poultry at the December Poultry Show.

LIME EXPERIMENTS.

The rather remarkable effects of the use of air-slacked lime upon the Station farm, as shown by the growth of a variety of crops, has attracted the attention of the public and led to considerable inquiry as to whether the general use of air-slacked lime in other parts of the State would prove equally beneficial. That some data might be obtained toward a solution of this question, specimens of soils from many localities have been examined and tested for acidity, and one experiment in the use of lime was tried in Westerly with marked beneficial results.

Taking the test for acidity as a guide we infer that the greater portion of the sandy loam land of this State, when being seeded to clover and grass, will be benefited by an application of air-slacked lime well worked into the soil. Barley, clover, and beets, by the marked difference in their growth upon adjoining plots of limed and unlimed soil, will perhaps best illustrate the benefit of the use of lime wherever conditions exist which make its use necessary. We hope another season to have a limited number of experiments in different parts of the State for the purpose of learning more about this very important subject. If conditions like those existing in the sandy loam plain land of the Station farm prevail in the greater part of the sandy loam lands of the State, and applications of air-slacked lime will produce equally good results, then a general adoption of the practice by the farmers of the State will mean an enormous increase in the crops of clover and hay, and corresponding benefit to our agriculture.

STATION INSPECTION.

The Fifty-third Congress of the United States in making the usual appropriation for the Experiment Stations stipulated that the Secretary of Agriculture should prescribe the form of the annual financial statement, ascertain whether the expenditures were in accordance with the act, and report to Congress. The text of the sentence authorizing the inspection of the Stations is as follows:

> The Secretary of Agriculture shall prescribe the form of annual financial statement required by section three of the act of March second, eighteen hundred and eighty-seven; shall ascertain whether the expenditures under the appropriation hereby made are in accordance with the provisions of the said act, and shall make report thereon to Congress.

Under this law schedules and blanks providing for an itemized classification of all expenditures were provided by the Secretary of Agriculture and an inspector detailed from the Office of Experiment Stations to make a personal visit and inquire into the work of, and conditions affecting, each Station.

This Station was visited by the inspector in September and many helpful suggestions were obtained from him. The inspection is in the line of enforcing a strict conformity with the provisions of the Hatch Act, believing that scientific agricultural *investigation* will in the end prove of most value to agriculture. We fully believe that the annual visit of a representative of the Secretary of Agriculture will prove very helpful to the Station.

CORRESPONDENCE.

There has been a constantly increasing volume of correspondence in all the divisions of the station. With the aid of the services of a good stenographer the demand upon the time of the various members of the station staff has been but little greater than heretofore, while the entire matter of correspondence has been systematized and improved.

In closing, I would extend to the farmers and citizens of the State a most hearty invitation to visit the Station grounds and see the work in progress and some of the results obtained. I wish also to express my thanks to the members of the station staff and others who by their earnest and faithful service have contributed largely to the measure of success attained.

ON THE RELATIVE GROWTH OF COMMON SORREL (*RUMEX ACETOSELLA*) AND CLOVER UPON AN UPLAND ACID SOIL BEFORE AND AFTER LIMING.

C. O. FLAGG, H. J. WHEELER, AND G. M. TUCKER.

The results to be given in this connection were obtained upon the twentieth acre plots, a full description of the treatment of which can be found elsewhere.[1] The same general system of manuring has been employed upon these plots from 1890 until the present time with the exception of 1895, when no manure was applied. Each of the plots had heretofore received an equal amount of potash and phosphoric acid annually in the form of muriate of potash and dissolved boneblack. Plots 8 and 9 received each year in addition a two-thirds and full ration of nitrogen respectively in the form of nitrate of soda. Plots 10, 11 and 12 have each received in addition a one-third, two-thirds, and full ration of nitrogen respectively, in form of sulphate of ammonia. Plots 13, 14 and 15 have also each received a one-third, two-thirds, and full ration of nitrogen respectively, but in the form of dried blood. The quantities of nitrate of soda, sulphate of ammonia and of dried blood have been varied according to the composition of the materials used, so that the full ration of nitrogen applied each year, has remained identical. Indian corn was grown upon these plots in the four years prior to 1894. In the spring of 1894 the plots were seeded to oats and clover. The north ends of those plots which received nitrogen in the form of sulphate of ammonia,[1] (10, 11 and 12) received for a distance of fifty-two feet a dressing of air-slacked lime in 1891 at the rate of about five tons per acre, and in 1892 a further application was made at the rate of 3.3 tons per acre. Since that date no further application of lime has been made upon these sections. In 1893, however, an application of lime at the rate of two and a half tons per acre was made upon the southern third of each of the plots employed in this experiment. In harvesting the clover in 1895 no record of the weights upon the limed section upon the north ends of the plots which received sulphate of ammonia, (10, 11 and 12) was made. The weights embodied in the following tables are those of the crop obtained upon the southern third or limed end of the plots. Upon the unlimed sections weighable quantities of clover were not present, the plants having been almost totally destroyed by the condition of the soil. The weights given below were taken as rapidly as the material was cut, or in other words, with as little drying as possible. This was done in order that discrepancies in weights due to unequal drying might be avoided, it having been impossible at the time to determine the percentage of water in the crop removed. Though the weights of the clover, weeds, etc., were taken upon small areas, it was impossible owing to their small size to obtain thereby a strictly comparable basis for the calculation of the relative quantities of clover and other plants removed from each plot, and the time and labor involved in separating the clover from the sorrel and other weeds; upon areas of large size was so great as to practically forbid, at that time, an attempt to assort the material thus harvested. For the reasons above mentioned, the total weight of the material removed from the limed ends of the plots is

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[1] Third Annual Report, pp. 49-56; Fourth Annual Report, pp. 40-46; Fifth Annual Report, pp. 167-171; Sixth Annual Report, pp. 196-201; Seventh Annual Report, pp. 111-114.

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[1] The quantities and dates of the applications of lime as given in the Seventh Annual Report of this Station p. 118, are incorrect and do not, as may be seen, agree with those above given.

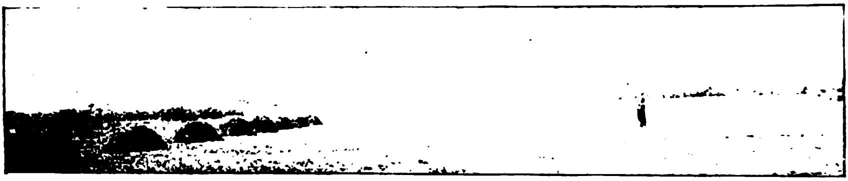
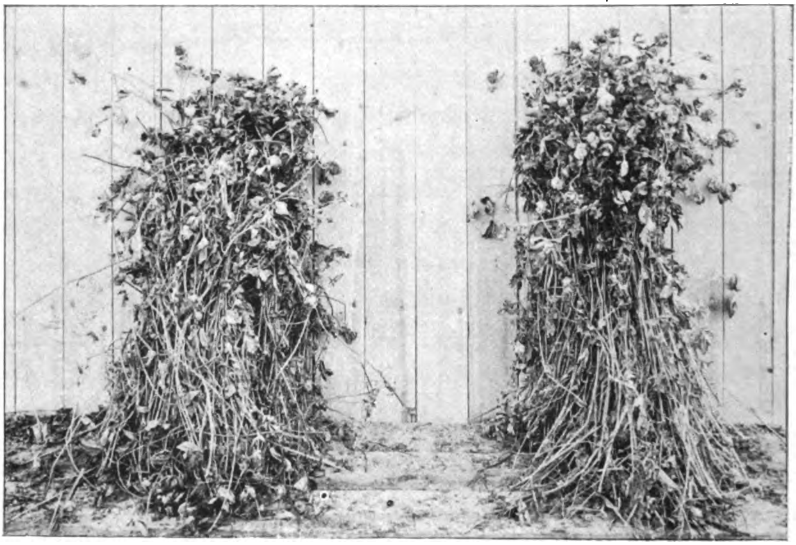


Fig. 1. Clover Field. (second crop).

Clover. (Limed ends of plots). No Clover. (Unlimed ends of plots).

(*See bottom of page 195*).



Plot 6c. **Fig. 2.** Red Clover. Plot 15.

Both plots were manured alike with potash and phosphoric acid from 1890 to 1894 inclusive. Plot 15 received in addition annually from 1,150 to about 1,500 lbs. of dried blood per acre.

(*See end of foot-note, page 195*).

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given, and it should be stated that varying[1] quantities of sorrel and small quantities of Timothy (*Phleum pratense*) were present with the clover. Upon the unlimed sections no Timothy was visible, upon a casual inspection, and only a trace of clover was here and there to be found, the land being occupied by weeds consisting chiefly of sorrel. In regard to the Timothy, it should be stated that no seed was sown upon the plots, yet where lime was applied either seed which was in the soil already or else some which may have been mixed with the clover seed germinated and grew; and here and there among the clover vigorous clusters of Timothy were to be seen standing high above the clover both in the first and second crops. Upon the unlimed portions of the plots, however, only traces of Timothy could be discerned and then only after a most careful search. The value of lime in connection with Timothy upon our acid soil was therefore most strikingly manifest and was in full accord with the results secured with it in the experiment with grasses upon limed and unlimed soil described elsewhere in this report.

The weights per acre of clover together with the sorrel, a small amount of Timothy and miscellaneous weeds, as obtained from the southern limed sections of the plots, are given in the subjoined table. As will be seen from the table, no weights of material were given from the unlimed sections of the plots, for the reason that here no weighable quantities of clover or Timothy were present, the land being almost wholly occupied by weeds. (*See accompanying illustration showing the growth of clover and weeds respectively upon the limed and unlimed sections of the plots in both the first and second crops.*)

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[1] The growth of oats upon the limed portions of these plots was greatest in 1894 where the greatest quantities of nitrogen were employed, a condition which caused them to lodge more than upon the other plots. In consequence of the lodging, the clover upon these plots was killed, and subsequently upon the removal of the oats, sorrel occupied these vacant spaces to a greater or less extent, so that more sorrel and less clover was produced upon the plots which received the full ration of nitrogen than upon any of the others. Aside from the above-mentioned spots no appreciable difference in the height and vigor of growth of the clover upon the limed sections of the plots was noticeable even when those which had previously received no nitrogen were taken into consideration.

TABLE SHOWING THE YIELD PER ACRE OF UNDRIED CLOVER[1] UPON LIMED AND UNLIMED PLOTS.

(Each plot received potash and phosphoric acid in the same forms and quantities.)

NUMBERS OF PLOTS.	FIRST CROP.		SECOND CROP.		TOTAL YIELD.	
	Limed.	Unlimed.	Limed.	Unlimed.	Limed.	Unlimed.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
No. 6a without nitrogen..	1800	....	1800	....	3600	..
No. 6b " "	3000	....	2100	. .	5100	....
No. 6c " "	3000	....	2400	....	5400	...
Average of 6a, 6b and 6c.	2600	....	2100	....	4700	....
No. 13, 220 lbs. dried blood	3300	....	3000	....	6300	....
No. 14, 440 " "	3000	....	2700	....	5700	....
No. 15, 660 " "	3000	....	2250	...	5250	....
No. 10, 166 lbs. sulphate of ammonia.........	2700	....	2100	....	4800	...
No. 11, 232 lbs. sulphate of ammonia.........	3000	....	1800	....	4800	....
No. 12, 348 lbs. sulphate of ammonia.........	2250	....	1800	....	4050	....
No. 8, 300 lbs. nitrate of soda	1650	....	2550	....	4200	....
No. 9, 450 lbs. nitrate of soda.	1500	....	2100	...	3600	....

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[1] The clover was mixed with a little Timothy, varying amounts of sorrel, and a few miscellaneous weeds.

The foregoing table, in connection with what has preceded it, is practically self explanatory, and from it and the accompanying illustrations the almost marvelous effect of lime upon the growth of clover upon this soil is readily seen.

As previously indicated, small areas four square feet in extent, which were selected for the purpose of securing as fair a representation as possible of the character of the growth upon the limed and unlimed sections of certain of the plots, were measured off and the plants upon the same assorted and weighed. It was impossible of course by the employment of such small areas to secure results strictly representative of the entire sections from which they were taken, yet the data obtained in this way appear to be of sufficient interest to warrant their publication in this connection; they have therefore been collected in the following table:

TABLE SHOWING WEIGHTS OF PLANTS UPON AREAS TWO FEET SQUARE, FROM LIMED AND UNLIMED PLOTS.

PLOT NUMBER.	Clover.	Sorrel.	Timothy.	Miscellaneous weeds.
	Lbs.	Lbs.	Lbs.	Lbs.
6c, limed, no nitrogen	3.26	0.06	0	trace
6c, unlimed, no nitrogen	0.00	1.35	trace	0.05
15, limed, full ration of dried blood	3.00	1.00	0.09	0.00
15, unlimed, full ration of dried blood	trace	0.95	0.00	0.05
9, unlimed, full ration of nitrate of soda	trace	0.70	trace	0.00
12, unlimed, full ration of sulphate of ammonia	0.00	3.50	0.00	trace

For the purpose of comparing the relative growth of clover and sorrel, small areas were selected upon the limed and unlimed sections of two particular plots. Plot 6a was selected for the purpose of securing comparisons where the real effectiveness of the lime could best be observed. This plot was one of those which had received no nitrogen in previous years, in consequence of which, the product of oats in 1894 was small, owing to which fact lodging did not result so that the clover had full opportunity to show the benefit derived from liming. Similar areas were selected upon plot 15, which had received in previous years, in addition to the manures which had been applied to plot 6c, a full ration of nitrogen in the form of dried blood. The yield of oats upon this plot was so great in 1894 that they lodged somewhat and thereby killed some of the clover, the room of which was in consequence occupied by sorrel to some extent in 1895.

As will be seen from the foregoing table no clover was noticeable from the area upon the unlimed section of plot 6c, while the sorrel amounted to 1.35 lbs. From the area of the limed section of the same plot 3.26 lbs. of clover were obtained and only 0.06 of a pound of sorrel. From the area of the unlimed section of plot 15 where a full ration of nitrogen in the form of dried blood was employed, only a trace of clover was found and the sorrel amounted to 0.95 of a pound. From the area upon the limed section of the same plot 3 lbs. of clover and 1 lb. of sorrel were obtained.

Another interesting feature which is brought out in the foregoing table is the relative growth of sorrel upon the unlimed sections of plots 9, 12 and 15. Each of these plots had been manured from 1890 to the present time with exactly the same amounts of potash, phosphoric acid and nitrogen, the only difference having been that the nitrogen employed in plot 9 was in the form of nitrate of soda, that upon plot 12 was in the form of sulphate of ammonia and that upon plot 15 in the form of dried blood. During the years from 1890 to 1894 inclusive, the growth upon plots 9 and 15 was good, that upon the former having been perhaps somewhat better than that upon the latter. Upon plot 15, however, where a full ration of nitrogen in the form of sulphate of ammonia was used as in the other cases without the employment of lime, the crops were without exception practically a failure. The reason of this had been attributed to the lack of bases in the soil which resulted in its becoming acid, in consequence of which the sulphate of ammonia was evidently not only not nitrified to any considerable extent, but it also acted poisonously upon Indian corn and oats as above intimated. In consideration of this fact it

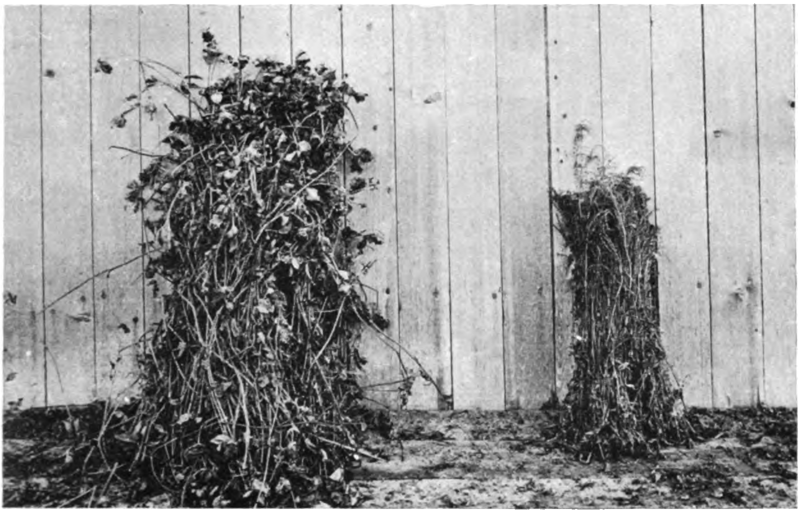

FIG. 3. **Plot 6c.**

Red Clover with but little sorrel. | **Common sorrel and no clover.**
Limed. | **Unlimed.**

Plot 6c. manured with potash and phosphoric acid from 1890 to 1894 inclusive. (*No nitrogen*).

(*See table, page 197*).

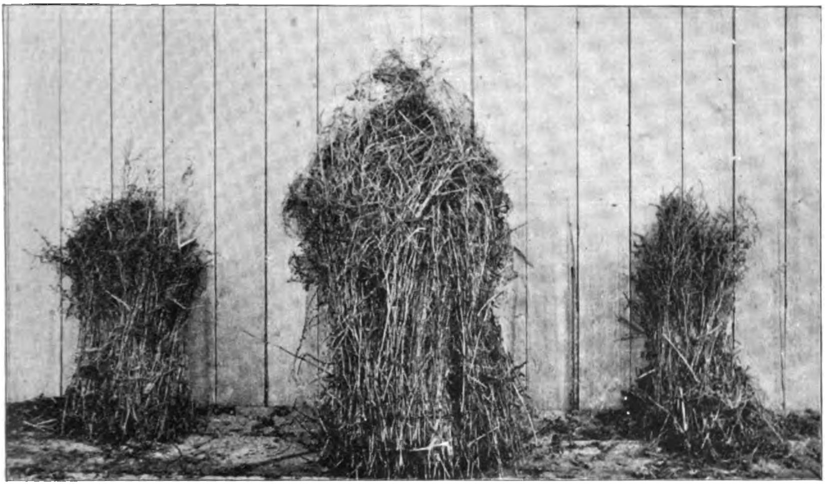

FIG. 4. COMMON SORREL.

Plot 15. **Dried blood.** | **Plot 12.** **Sulphate of ammonia.** | **Plot 9.** **Nitrate of soda.**

Manured alike with potash and phosphoric acid and with like *quantities* **of nitrogen in the respective forms. All from** *unlimed* **sections of the plots.**

(*See third paragraph, page 198*).

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is of marked interest to note that the product of sorrel was, nevertheless, more than three and a half times as great as upon the corresponding sections of plots 9 and 15, from which it appears that sorrel is able to grow most luxuriantly and even far better under conditions which prove almost wholly destructive to Indian corn and oats, than under conditions which are favorable to the growth of the latter.

SUMMARY.

The growth of clover upon the plots which had received no nitrogen in any form, at least for five and probably for a dozen years, was nearly if not quite as good as upon those which had received a large annual application from 1890 to 1894 inclusive, a result decidedly in contrast to those secured with Indian corn and oats upon the same plots.

The injury liable to result to a clover crop owing to the smothering of the young plants by the lodging of the accompanying grain crop, the necessity for thin seeding, and care not to employ too much nitrogen in such cases, is pointedly illustrated.

Fresh applications of lime have appeared in other experiments to be unfavorable to the growth of sorrel. It appears probable, however, that the chief value of lime in eradicating sorrel is attributable to the fact that it brings about physical and chemical soil conditions, one or the other or both of which, are so highly favorably to the growth of clover and many other agricultural plants, that they are able to occupy the land, thereby preventing sorrel from gaining a foothold.

FURTHER OBSERVATIONS FOR THE PURPOSE OF DETERMINING IN HOW FAR THE RESULTS SECURED IN A SOIL TEST WITH A GIVEN PLANT ARE APPLICABLE TO OTHERS.

H. J. WHEELER AND G. M. TUCKER.

This experiment was conducted upon the plots which had been used for the soil test during the five years 1890 to 1894, inclusive. Indian corn was grown during the first four years and this showed, subsequent to the first year of the trial, that the soil was chiefly deficient in phosphoric acid. In 1894, thirty-seven varieties of plants were grown upon these plots for the purpose of ascertaining if the results secured with each of them would accord with those previously obtained with Indian corn. With three exceptions these plants indicated that the soil needed phosphoric acid more than nitrogen or potash. The white bean, sunflower and summer squash indicated a greater deficiency of potash than of phosphoric acid. It should be stated, however, that only two rows of each of these plants were employed in 1894, the experiment having been conducted for the purpose of securing indications which might serve as a basis for future experiments and not with the expectation that final conclusion could be drawn therefrom. In pursuance of this idea a less number of plants was grown in 1895, and the number of rows, particularly of those kinds which indicated in 1894 a greater deficiency of potash than of phosphoric acid, was much increased. So far as concerned the arrangement of the plants, each plot was divided into two equal sections, which will be referred to as the north and the south ends. Upon both ends of the plots the plants were arranged in the same order and a like number of rows was employed upon each. The number of rows and the order of their arrangement from north to south was as follows: crimson clover four, golden millet three, Swedish turnip two, spring rye two, oats two, barley two, wheat two, white beans five, string beans two, sunflower eight, summer squash, variety white scallop four, and variety crookneck four. From observations upon the growth of the plants upon plots 4, 5 and 6 it became evident early in the season that the lots of fertilizer intended for these plots had in some manner been interchanged, the indications being that that intended for plot 4 had been put upon plot 5, and that for plot 5 upon plot 4. It does not appear probable that plot 6 was involved in this interchange. That such an interchange had probably occurred in connection with plots 4 and 5 was self-evident to one who had watched the experiment carefully since its beginning in 1890, for in the succeeding years the crops had been almost a perfect failure upon plot 5 owing, presumably, to a deficiency of phosphoric acid, and since the growth upon that plot was better in 1895 than it was upon plot 4, circumstantial evidence of the strongest character was afforded that the fertilizers intended for these two plots had been interchanged. Swedish turnips have shown in our experiments the same dependence upon easily assimilable phosphoric acid which has been claimed for them in England, and their failure upon plot 4 in 1895, furnished further evidence that the potash and nitrogen intended for plot 5 must have been applied to this plot. Owing to this unfortunate occurrence, the only plots which furnish any evidence upon the point immediately under consideration are Nos. 1, 2 and 3. The weights upon the remaining plots have been introduced here merely as a matter of record in order that they may be used in connection with the results obtained upon these plots in subsequent years in ascertaining if an after effect will be visible from the phosphoric acid supposed to have been applied by mistake to plot 5 in 1895. The yields obtained upon the seven plots embraced in this experiment are given in the subjoined table. The yields from the rows at the north and south ends are given separately, and also an average of the two. Attention should also be called to the fact that the south end of plot 7 had been previously limed, while the north end had not, so that it was impossible to average the results from the two ends, as in the case of the other plots which had not been limed.

The results upon plots 4, 5, 6 and 7 must necessarily be omitted from consideration so far as concerns any data which they may furnish in relation to the question under investigation. The weights of white beans given in the preceding table are those obtained from the north ends of the plots. In this particular instance there was an inadequate supply of seed of the same lot, and that which was used upon the south ends germinated poorly and in consequence made the results so irregular that the crop was not weighed. It will be seen that the yields of crimson clover and golden millet were much greater upon the north ends of the plots than upon the south ends, and it is probable that this was due to inequalities in the pre-existing fertility of the ends of each plot, the existence of which was shown by the increased size of the Indian corn upon the north ends of the plots prior to 1894. For this reason the yields from the south ends of the plots in the case of the clover and millet above mentioned are probably the only ones which are fully reliable. Taking this point into consideration it will be seen that the results secured from plots 1, 2 and 3 with the various crops employed are practically in accord and show that the deficiency of phosphoric acid was greater than that of nitrogen or potash. The only possible exception to this is, perhaps, the white beans, the difference in the yields of which was not sufficiently great to furnish a basis for such a conclusion.

TABLE, SHOWING THE WEIGHTS, IN POUNDS, OF THE DIFFERENT CROPS AT THE TIME OF HARVESTING.

NAMES OF CROPS.	PLOT 1.		PLOT 2.		PLOT 3.		PLOT 4.		PLOT 5.		PLOT 6.		PLOT 7.	
	Nitrate of Soda, 24 lbs.		Dissolved Bone-black, 30 lbs.		Muriate of Potash, 10 lbs.		Nitrate of Soda, 24 lbs. Dissolved Bone-black, 30 lbs.		Nitrate of Soda, 24 lbs. Muriate of Potash, 10 lbs.		Dissolved Bone-black, 30 lbs. Muriate of Potash, 10 lbs.		Dissolved Bone-black, 30 lbs. Muriate of Potash, 10 lbs. Nitrate of Soda, 24 lbs.	
	North and South Rows.	Average of Rows.	North and South Rows.	Average of Rows.	North and South Rows.	Average of Rows.	North and South Rows.	Average of Rows.	North and South Rows.	Average of Rows.	North and South Rows.	Average of Rows.	North Row Unlimed.	South Row Limed.
Crimson Clover	11.00 1.25	6.13	7.20 9.45	8.33	6.10 0.65	3.38	12.50 14.60	13.55	17.65 9.10	13.38	9.00 6.60	7.80	15.05	17.15
Golden Millet	10.30 0.25	5.28	7.50 9.80	8.65	3.35 0.65	2.00	19.60 11.45	15.53	16.25 9.65	12.95	21.05 12.60	16.83	27.60	26.70
Swedish Turnips	0.00 0.00	0.00	6.30 2.30	4.30	0.00 0.00	0.00	1.40 0.00	0.70	11.75 9.50	10.63	11.50 4.30	7.90	14.80	31.65
Spring Rye	Trace. Trace.	Trace.	0.40 0.50	0.45	0.10 0.05	0.08	0.55 0.50	0.53	0.70 0.75	0.73	0.70 0.70	0.70	0.95	1.00
Oats	0.10 0.00	0.05	0.95 0.80	0.88	0.10 0.15	0.13	1.05 0.85	0.95	1.40 1.40	1.40	1.90 1.40	1.65	2.70	1.85
Wheat	0.00 0.00	0.00	0.10 0.05	0.08	0.00 0.00	0.00	0.50 0.05	0.53	0.70 0.15	0.43	1.30 0.35	0.83	1.40	2.55
White Beans	0.65	....	0.50	....	0.70	....	2.10	....	3.80	....	3.50	....	5.00	....
Sunflower	0.00 0.65	0.33	18.40 8.70	13.55	0.55 0.00	0.28	18.95 18.55	18.75	30.10 34.50	32.30	57.55 52.35	54.95	93.05	131.85
Scallop Squash	0.00 0.00	0.00	1.50 0.10	0.80	0.00 0.00	0.00	1.90 2.00	1.95	5.00 2.80	3.90	3.30 8.55	5.93	18.40	11.60
Crooked Neck Squash	0.00 0.00	0.00	0.10 0.05	0.08	0.00 0.00	0.00	1.30 1.60	1.45	3.40 4.40	3.90	6.35 21.00	13.68	18.65	22.30

SUMMARY.

In an experiment with thirty-seven varieties of plants which was conducted in 1894, it was found that all but three of them indicated that the soil was more deficient in phosphoric acid than in nitrogen or potash. The three apparent exceptions were the white beans, sunflower and summer squash. Those plants which showed a greater deficiency of phosphoric acid in 1894 have been retested this season with the same result. The results with beans in 1895 have not been conclusive, but those with the sunflower and the summer squash show a greater deficiency of phosphoric acid than of nitrogen or potash, and contradict, therefore, the indications afforded by the test with two rows only, in 1894. When it is considered, however, that sixteen rows each of sunflowers and of summer squashes were employed in 1895, and but two rows of each in 1894, it will be seen that strong evidence is afforded that the 1894 results were merely incidental, and that of the thirty-seven plants which have been tested in the two years probably not one would fail, under satisfactory conditions, to show a deficiency of phosphoric acid in the soil. For the purpose of arriving at fully definite conclusions in regard to this point it is hoped to continue the experiment, particularly with beans, and perhaps with sunflowers and summer squashes, for at least another season. If it is found that the results with a given plant will answer the question as to the fertilizer requirements of soils so far as concerns all of the plants usually grown upon the farm, one possible barrier in the way of the more general adoption of soil tests by this means will have been removed. It may not be impossible that what is true of phosphoric acid in this particular may not apply to potash, a question which could be best studied upon a soil more deficient in that element than our own.

FURTHER OBSERVATIONS UPON THE GROWTH OF VARIOUS PLANTS UPON AN UPLAND ACID SOIL BEFORE AND AFTER LIMING.

H. J. WHEELER AND G. M. TUCKER.

The observations recorded in the following pages are a continuation of those given in the Sixth Annual Report of this Station for 1893, pp. 224–252, and in the Seventh Annual Report for 1894, pp. 152–167. A description of the plan and arrangement of the permanent experimental plots, of which plots 23, 25, 27 and 29 form a part, may be found in the Fourth Annual Report of the Station for 1891, pp. 13–15.

Some modifications of the previous manuring were made in 1895 as follows: owing to the known deficiency of phosphoric acid in this soil, the amount of dissolved boneblack was increased from 600 to 800 pounds per acre; the amount of muriate of potash was increased from 180 to 350 pounds per acre; the amount of nitrate of soda remained the same as in 1894, while the quantity of ammonium sulphate which varied slightly in composition from that previously used was so modified that the amount of nitrogen furnished by it would be identical with that applied in the nitrate of soda. Plots 25 and 29, which are the only ones in this experiment which have received an application of lime at any time, were given a dressing at the rate of 5400 pounds per acre in 1893, and of 1000 pounds per acre in 1894, no further application having been made in 1895. Heretofore no application of magnesia had been made to any of the plots, but in 1895 sulphate of magnesia (Epsom salts) was applied to all at the rate of 200 pounds per acre.

This was done for the reason that previously better results were obtained from the limed plot which received nitrate of soda than from the other limed plot which received sulphate of ammonia, differences which might have in part been attributed to the liberation of magnesia by the soda. The particular feature of the experiment as conducted in 1895 has been the introduction of the test of the effect of liming upon the development of a number of the more important grasses which are already, or might perhaps be grown to advantage in this State. The observed differences in the effect of liming upon the various cereals and also the very different effect of the same upon individual members of the leguminous and other families of plants, made it seem reasonable that the grasses might differ similarly in this particular. In view of the fact that many of the soils of the State have been found to be acid, therefore indicating their probable deficiency in carbonate of lime, it seemed likely that the use of lime and wood ashes might become more general in Rhode Island than formerly; and consequently a knowledge of the effect of their application upon the growth of the more common grasses promised to be of particular economic value. A number of miscellaneous plants which have been grown on one or two previous occasions have been retested in order that the data in relation to them might be increased to such an extent as to render the conclusion drawn, of greater value than would otherwise be possible. In 1893, the first year of the experiment, carrots showed a decided benefit from liming. In 1894 they appeared to have been injured, while in 1895 an even more marked benefit from liming has been observed than in 1893. Whether this was due merely to some exceptional conditions which existed in 1894, or not, cannot be definitely stated. In view, however, of the fact that two successive annual applications of air-slacked lime had been made just previous to the time when the apparently injurious action was noted, the possibility suggests itself that fresh applications of lime in considerable quantity may not be beneficial to carrots, even though they may be subsequently benefited by it, provided a year or more has been allowed to elapse after the liming, before they are grown. That such conditions as this might result does not seem at all impossible, and the only way by which final conclusions in relation to such points may be reached is by a persistent repetition of experiments and continuity of effort. In general the results obtained from the various plants during the three years of the experiment have been practically in accord so far as concerns positive benefit or injury from liming. The following table gives the results obtained in 1895 with the exception of the weight of the Timothy from the four plots which by some misfortune was not recorded, a fact which is much to be regretted owing to its having been one of the grasses which was benefited by lime in a striking degree:

PLOT Nos.	23	25	27	29	Per cent. of gain (+) or loss (−) on Plot 29 relative to Plot 25.	Yields on Plot 29, reckoning those on Plot 27 as 1.		
	Lbs. Per Acre.							
Fertilizers Applied in 1895:								
Dissolved Boneblack	800.0	800.0	800.0	800.0				
Muriate of Potash	350.0	350.0	350.0	350.0				
Sulphate of Magnesia	200.0	200.0	200.0	200.0				
Sulphate of Ammonia	362.4	362.4	....	....				
Nitrate of Soda	....	....	465.0	465.0				
Air-slacked Lime	....	6400.0	....	6400.0				
NAMES OF CROPS.	Lbs. Per Row.					1895	1894	1893
GRASSES.								
Awnless Brome Grass (*Bromus inermis*).	11.25	27.00	17.75	27.50	+ 1.85	1.55	....	....
Meadow Fox-tail (*Alopecurus pratensis*).	21.75	41.00	36.25	47.00	+ 14.63	1.30	....	....
Tall Fescue (*Festuca elatior*).	30.25	42.50	36.00	44.50	+ 4.71	1.24	....	....
Kentucky Blue Grass (*Poa pratensis*).	1.00	16.00	11.00	13.25	− 17.19	1.20	....	....
Red Top (*Agrostis vulgaris*).	26.00	28.00	24.00	28.00	0.00	1.17	....	....
Orchard Grass (*Dactylis glomerata*).	25.75	42.00	40.50	47.00	+ 11.90	1.16	....	....
Meadow Oat Grass (*Avena elatior*).	30.75	34.75	35.25	38.25	+ 10.07	1.09	....	....
Soft Grass (*Holcus lanatus*).	72.25	75.25	68.75	69.75	− 7.33	1.01	....	....
Rhode Island Bent (*Agrostis canina*).	23.00	25.27	21.00	20.75	− 17.89	0.99	....	....
Sweet Vernal (*Anthoxanthum od. puelli*).	5.75	9.25	9.00	8.00	− 13.51	0.89	....	....
Sheep's Fescue (*Festuca ovina*).	8.75	2.50	1.25	1.25	− 50.00	0.00	....	....
VEGETABLES.								
Onions (Egyptian)	0.00	2.00	0.05	1.55	− 22.50	31.00	9.00	....
Celery	0.05	10.55	0.50	13.80	+ 30.81	27.60	9.42	....
Onions (Barletta)	0.00	9.70	2.50	19.70	+103.09	7.88	8.12	....
Pumpkins	0.00	48.60	25.00	134.05	+175.82	5.36	0.55	....
Beets (Mangel-wurzel)	0.10	90.65	24.10	119.25	+ 31.55	4.95	5.77	7.59
Muskmelon	0.00	47.90	26.40	64.60	+ 34.86	2.45	4.70	....
Carrots	0.15	83.85	43.00	84.45	+ 0.72	1.96	0.71	1.78
Table Beets	0.20	105.70	54.10	99.45	− 4.97	1.84	5.85	4.22
Cabbage—trimmed heads	0.60	70.40	57.10	97.15	+ 37.99	1.70	10.14	....
Kohl-rabi	1.80	57.50	33.50	53.55	− 6.87	1.60	1.59	....
Dandelion*	0.00	20.62	13.55	23.58	+ 14.35	1.74	1.08	....
Kohl-rabi—transplanted	0.05	7.20	6.45	10.15	+ 40.97	1.57	....	....
Flat Turnip	28.50	124.00	80 00	107.30	− 13.46	1.34	1.29	....
Watermelon	136.00	20.60	104.75	57.10	+177.18	0.55	0.64	....

* Average of three cuttings.

PLOT Nos.		23	25	27	29	Per cent. of gain (+) or loss (−) on Plot 29 relative to Plot 25.	Yields on Plot 29, reckoning those on Plot 27 as 1.		
Fertilizers Applied in 1895:		Lbs. Per Acre.							
Dissolved Boneblack		800.0	800.0	800.0	800.0				
Muriate of Potash		350.0	350.0	350.0	350.0				
Sulphate of Magnesia		200.0	200.0	200.0	200.0				
Sulphate of Ammonia		362.4	362.4	....	....				
Nitrate of Soda		....	....	465.0	465.0				
Air-slacked Lime		....	6400.0	....	6400.0				
NAMES OF CROPS.		Lbs. Per Row.					1895	1894	1893
CEREALS.									
Barley	North row.	0.15	17.70	6.25	13.55	....	2.17	....	....
	South row.	0.20	16.05	2.45	17.60	....	7.18	....	....
	Average	0.18	16.88	4.35	15.58	− 7.70	3.58	2.06	1.80
Wheat	North row.	0.35	7.10	2.75	4.70	....	1.71	....	....
	South row.	0.40	6.70	2.50	5.35	....	2.14	....	....
	Average	0.38	6.90	2.63	5.03	− 27.10	1.91	1.40	....
Sweet Corn	Ears	1.25	23.20	10.25	18.75	....	1.83	....	....
	Stover	3.15	36.60	14.75	18.50	....	1.25	....	....
	Total	4.40	59.80	25.00	37.25	− 37.70	1.89	1.11	2.07
Oats	North row.	7.80	8.15	7.55	8.00	....	1.06	....	....
	South row.	9.15	12.20	8.75	9.50	....	1.09	....	....
	Average	8.48	10.18	8.15	8.75	− 14.04	1.07	1.09	1.26
Field Corn	Total	2.15	22.35	20.90	22.25	− 4.47	1.06	0.61	0.71
Pop Corn	Ears	0.85	11.25	11.28	11.55	....	1.02	....	....
	Stover	4.90	31.05	33.28	34.43	....	1.03	....	....
	Total	5.75	42.30	44.56	45.98	+ 8.69	1.03	....	....
Millet (*P. crus-galli*)		11.45	17.20	19.00	15.60	− 9.29	0.82	0.90	0.87
Rye	North row.	2.50	3.50	2.70	1.75	....	0.65	....	....
	South row.	3.05	2.95	2.80	2.35	....	0.84	....	....
	Average	2.78	3.23	2.75	2.05	− 36.53	0.75	1.08	1.13
MISCELLANEOUS.									
Alfalfa. 1st crop		0.00	8.20	1.45	4.75	− 42.07	3.28	....	....
Alfalfa. 1st crop (air-dried)		0.00	2.02	0.34	1.25	− 38.12	3.68	....	....
Alfalfa. 2d crop		0.00	8.55	4.15	5.85	− 31.58	1.49	....	....
Sorrel		108.25	108.60	124.60	102.50	− 5.61	0.82	0.86	....
Serradella		39.05	39.65	56.55	39.05	− 1.51	0.69	....	....
Blue Lupine		30.50	29.25	44.00	25.75	− 1.19	0.59	....	....
Blue Lupine (air-dried)		5.92	5.99	8.71	5.48	− 8.51	0.61	0.23	0.47

From the foregoing tables it will be seen that the results with all of the vegetables with the exception of the pumpkin and watermelon, and of the carrot in 1894, point as in previous years, to benefit from liming. In the case of the pumpkin the growth of the plants early in the season seemed to be promoted by lime, yet they blighted earlier than the plants upon the unlimed plots, a condition which it was thought might possibly have been due to the spattering of the freshly limed soil upon the leaves, or to some change in the chemical composition of the plants whereby they were made more susceptible to disease. At all events, owing apparently to the early destruction of the vines upon the limed plot (29), the yield was, as will be seen, much less than upon the unlimed one (27). That no such effect was noticeable in 1895 may have been due to the fact that the lime had by that time lost entirely its caustic properties and had become more thoroughly incorporated with the entire mass of the surface soil. In 1895 the greater yield upon the limed plot was in striking contrast to the result obtained in 1894. Carrots show a marked gain from the use of lime, differing in that respect from the results secured in 1894 and agreeing with those of 1893. Whether the amount of lime present in 1894 in consequence of the two successive applications made in that and the preceding year, was the cause of this particular result remains to be ascertained, and it is possible that a continuation of the observations may show that it is more desirable to allow one or two crops to intervene between the liming and the growing of carrots and some other crops which have shown an injury from liming, than to grow them the same season that the lime is applied. The watermelon appeared to be injured by liming far more than in 1894. By comparing the results upon the limed and unlimed sulphate of ammonia plots (25 and 23) it will be seen that upon the unlimed plot (23) the watermelon was the only one among the vegetables, with the exception of the flat turnip, which was not a total failure, and it will be seen that even the flat turnip made upon this plot only a very inferior growth. It is highly interesting to note that the watermelon was able to make an ideal growth and to produce a splendid crop under conditions which proved almost wholly fatal to so many other plants. Comparing these results also with those secured with the muskmelon, it will be seen that the watermelon was injured by lime in

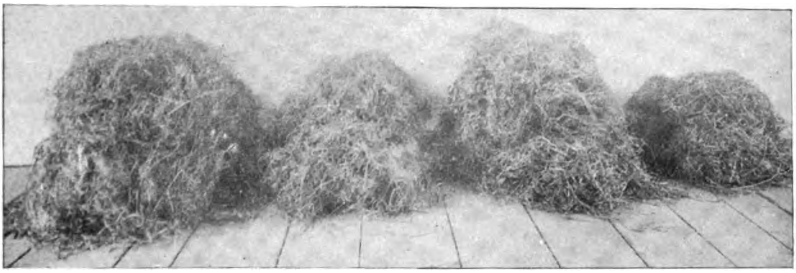

Fig. 1. Awnless Brome Grass.

Plot 29. Limed. Plot 27. Unlimed. Plot 25. Limed. Plot 23. Unlimed.
Nitrate of soda. Sulphate of ammonia.

All manured alike with potash and phosphoric acid.

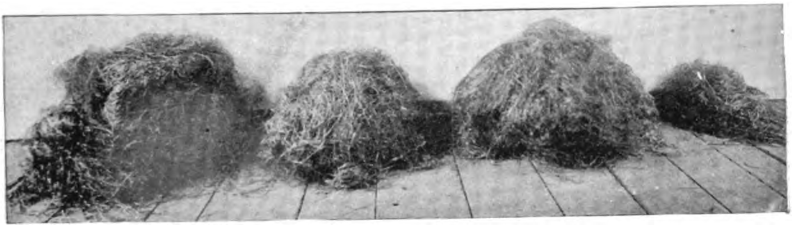

Fig. 2. Kentucky Blue Grass.

Plot 29. Limed. Plot 27. Unlimed. Plot 25. Limed. Plot 23. Unlimed.
Nitrate of soda. Sulphate of ammonia.

All manured alike with potash and phosphoric acid.

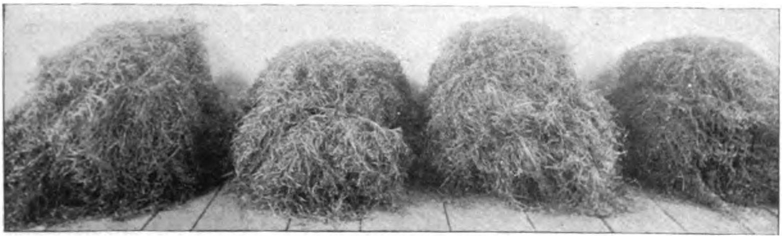

Fig. 3. Red Top.

Plot 29. Limed. Plot 27. Unlimed. Plot 25. Limed. Plot 23. Unlimed.
Nitrate of soda. Sulphate of ammonia.

All manured alike with potash and phosphoric acid.

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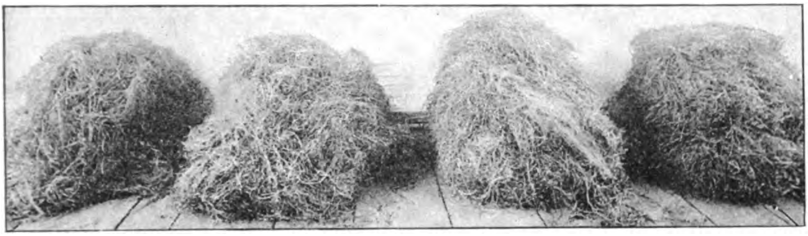

Fig. 4. R. I. Bent.

Plot 29 Limed. Plot 27. Unlimed. Plot 25. Limed. Plot 23. Unlimed.
Nitrate of soda. Sulphate of ammonia.

All manured alike with potash and phosphoric acid.

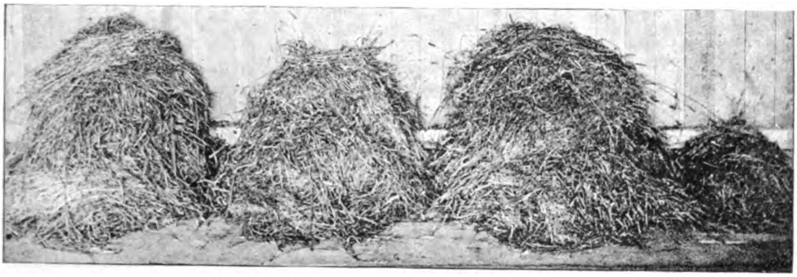

Fig. 5. Timothy.

Plot 29. Limed. Plot 27. Unlimed. Plot 25. Limed. Plot 23. Unlimed.
Nitrate of soda. Sulphate of ammonia.

All manured alike with potash and phosphoric acid.

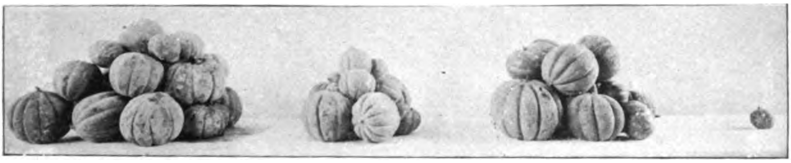

Fig. 6. Cantaloupe.

Plot. 29. Limed. Plot 27. Unlimed. Plot 25. Limed. Plot 23. Unlimed.
Nitrate of soda. Sulphate of ammonia.

All manured alike with potash and phosphoric acid.

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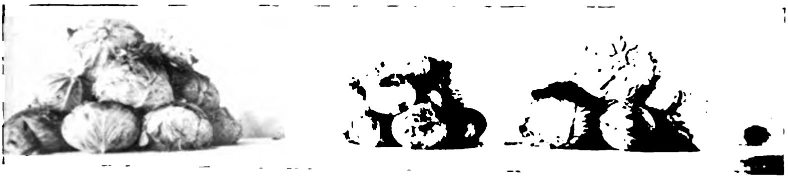

FIG. 7. CABBAGE.

Plot 29. Limed. Plot 27. Unlimed. Plot 25. Limed. Plot 23. Unlimed.
Nitrate of soda Sulphate of ammonia.
All manured alike with potash and phosphoric acid.

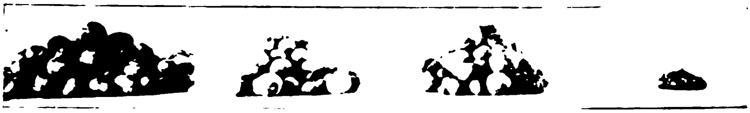

FIG. 8. KOHL-RABI.

Plot 29. Limed. Plot 27. Unlimed. Plot 25. Limed. Plot 23 Unlimed.
Nitrate of soda. Sulphate of ammonia.
All manured alike with potash and phosphoric acid.

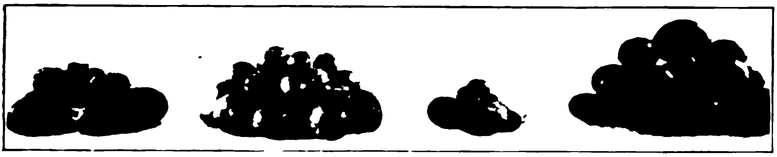

FIG. 9. WATERMELONS.

Plot 29. Limed. Plot 27. Unlimed. Plot 25. Limed. Plot 23. Unlimed.
Nitrate of soda. Sulphate of ammonia.
All manured alike with potash and phosphoric acid.

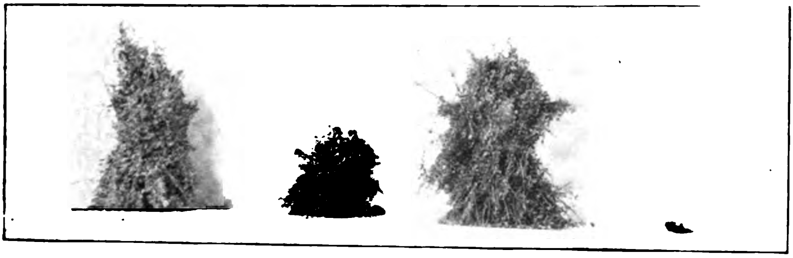

FIG. 10. ALFALFA.

Plot 29. Limed. Plot 27. Unlimed. Plot 25. Limed. Plot 23. Unlimed.
Nitrate of soda. Sulphate of ammonia.
All manured alike with potash and phosphoric acid.

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each case, while the muskmelon was highly benefited thereby, and particularly upon plot 23 most plants of the latter soon died, and not one of those remaining produced a melon, while the watermelons immediately beside them and under identically the same soil conditions, did as well as seemed possible under any circumstances.

In connection with the cereals and millet some interesting points are also observable. Rye has produced in 1895 a less yield upon the limed plot (29) than upon the unlimed one (27), and in 1893 and 1894 a hardly appreciable benefit was noticeable from liming. Oats have shown, as in previous years, a certain advantage from the use of lime, while wheat and barley agree with the results previously secured by exhibiting a still greater benefit from lime than that shown by oats. Comparing sweet corn (maize) with the field and pop varieties, the former appears as in previous experiments to have been benefited by lime, while the latter either shows no advantage, or a slight injury from its use. Millet has as in previous years failed to do as well upon the limed plot (29) as upon the unlimed one (27). Alfalfa, like clover, has been decidedly benefited by liming, while serradella and the blue lupine were apparently injured thereby. The lupine has shown less injury upon the limed plot (29) in 1895 than in 1894, which was doubtless due to the fact that some of the lime was still in a caustic state in 1894, which condition may have increased the ill effect. The same holds true also of the sorrel. The seeds of the various grasses were not sown until the spring of 1895, in consequence of which the weights embodied in the foregoing table represent simply those of the material produced during the first season, and if decided differences in their growth are caused by liming they would not be expected to become strikingly manifest before another year. The weights here given are published therefore chiefly as a matter of record, and conclusive results cannot be obtained at least before another season, and perhaps not even than. It may be stated, however, that a few grasses have shown thus far no benefit from liming, others a slight benefit, and still others a decided one. Timothy (*Phleum pratense*) appeared this season to be more benefited by lime than any other grass. The relative yield of certain of the grasses upon the four plots is shown by the illustrations herewith given. By a comparison of the weights obtained upon the limed and unlimed nitrate of soda plots (29 and 27) it will be seen that the Kentucky blue grass appears to have been less benefited by lime than the tall fescue, meadow fox-tail or awnless brome grass, yet upon the unlimed sulphate of ammonia plot (23) it was, as will be seen, injured more than any one of the above mentioned grasses; and it may be stated that in general those plants that have shown the greatest injury upon this plot have been, with rarely an exception, those most benefited by lime, and it will be an interesting matter to observe whether this proves true in this case, upon a continuation of the experiment. It will be seen, furthermore, by reference to the table that the sheep's fescue like the watermelon, lupine and sorrel, seems to have remained uninjured upon the unlimed sulphate of ammonia plot (23) upon which many plants either failed utterly or were seriously injured. From the foregoing it will be obvious that almost as great differences exist among the grasses so far as concerns the effect of liming as have been observed between the kinds of melons, cereals and leguminous plants. Another point of marked interest is brought out by a further study of the foregoing tables, as follows: it will be seen that the yields obtained from a large number of plants were greater in 1895 upon the limed sulphate of ammonia plot (25) than upon the corresponding one (29) which received nitrate of soda. In 1893 the majority of the plants upon the nitrate of soda plot, above mentioned, gave better results than upon that which received sulphate of ammonia, and in 1894 this was the case almost without exception. The question naturally suggests itself whether these results are not merely incidental? It seems most desirable to continue these observations long enough and under conditions suitable for determining the real cause for these apparently conflicting results. It must be borne in mind that applications of lime were made in both 1893 and 1894, no further amount having been used in 1895. Further applications of lime have been omitted for a time in order that its after effect in connection with its use with ammonium sulphate and sodium nitrate might be studied. Two or three possible explanations of the above-mentioned observations suggest themselves, namely: The soda which has accumulated within the soil as a result of the three successive applications of the nitrate of soda may have had an injurious effect upon certain plants, though this does not seem probable when we take into consideration the better results secured in 1894 than in 1893. It is possible that the sulphuric acid of the sulphate of ammonia may by its having furnished sulphur to the plants, have been of some particular benefit, as suggested in the report of these experiments for 1893, a point which has also been raised recently by G. Pagnoul and L. Grandeau,[1] in connection with certain experiments in France. If such were the case, however, it would seem surprising that the results of 1894 should not when compared with those of 1893 have pointed in the same direction. The most reasonable explanation which suggests itself at present seems to be that there may have been an insufficient supply of nitrogen upon the nitrate of soda plot (29) owing to a possible loss of the same by leaching, for it is generally conceded that nitrate of soda leaches more readily than sulphate of ammonia. The fact that the summer season of 1895 was a rainy one in comparison with the two which preceded it, further strengthens such an idea.

SUMMARY.

The following vegetables have shown this season, benefit from liming, decreasing in the following order: onions (Egyptian), celery, onions (Barletta), pumpkin, mangel wurzel, muskmelon, carrots, table beets, dandelion, cabbage, kohl rabi and flat turnip.

Carrots and pumpkins, which showed an apparent injury from lime in 1894, have given an increase upon the limed plots in 1895.

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[1] Jour. d'agricultur pratique, 1895, Vol. II, pp. 334-337, 337-338.

It is possible that these two plants should be introduced into a rotation a year or two after the lime has been applied, in order to secure the best results, a point which can only be ascertained with certainty by further experiments.

The watermelon showed a decided injury from liming in 1894, which was even more marked in 1895. In this particular the watermelon stands in marked contrast to the muskmelon, which was practically a failure both years except upon the limed plots.

Alfalfa, like clover, has shown a decided benefit from liming, while serradella and blue lupine have, on the contrary, been injured thereby. The injury to the lupine has been observed in each of the three years of the experiment, though it was greatest in 1894 immediately following the second application of lime.

Common sorrel has shown an injury from liming during both of the years in which it has been grown, though the injury was greatest in 1894 immediately following the second application of lime.

The observations with the different grasses indicate that Timothy, Kentucky blue grass, awnless brome grass and others, may be benefited by lime in varying degrees, while the sweet vernal, soft grass, Rhode Island bent and sheep's fescue, indicate less or no benefit from its use. These results with grasses, as has been stated previously, are those obtained from the first season's growth and cannot therefore be so conclusive or satisfactory as the results of succeeding seasons. It appears probable, however, that the individuality of the grasses in respect to their benefit or injury from liming, may be as great as that of the individual members of the leguminous, melon and other families of plants.

ON THE SUBSTITUTION OF SODA FOR, AND ITS VALUE IN CONNECTION WITH POTASH.

H. J. WHEELER AND G. M. TUCKER.

The question of the manurial value of sodium, particularly in the chemical combination known as common salt (sodium chlorid), has occupied the attention of agricultural writers and investigators for centuries. Much testimony as to the beneficial action of common salt is on record and much also to the contrary. Many of these experiments were conducted before much was known of the mineral requirements of plants so that no light could be thrown upon its direct nutritive value. In more recent times experiments have been conducted in which a beneficial action of common salt was observed, yet upon a chemical examination of the plants produced, an increased percentage of soda was not found, but on the contrary, more potash or an increased amount of other of the mineral constituents of plants. Such observations gave rise to the idea that soda was of no use as a direct manure but that it was valuable only by virtue of its indirect action in setting free within the soil other mineral constituents which are of direct manurial value to the plant. Until a comparatively recent date practically all agricultural writers and investigators may be said to have become united in the view that the sole benefit to be derived from soda in any of its combinations was that due to the above mentioned indirect action. Notwithstanding this, plants are known to contain varying amounts of soda, which has generally been considered as an incidental rather than an essential constituent. Recently this subject has received renewed attention by well-known agricultural investigators, namely: A. B. Griffiths, Wagner and Dorsch, Atterberg and Pagnoul, a more extended reference to whose observations has been made elsewhere.[1] The results secured by some of the experimenters above alluded to seem to show conclusively that sodium is to be considered as a direct plant nutrient, yet owing to the fact that the soil employed by Wagner was a very sandy one, and that the material which served as soil in the investigations conducted by Atterberg and Pagnoul was pure silica, it must be obvious that a conclusion drawn from these experiments to the effect that an application of soda to ordinary cultivated soils is necessary, is unwarranted by the data thereby afforded. Accepting the fact that soda is a plant nutrient it remains to be ascertained whether the amount of soda naturally existing in agricultural soils together with that contained in the barnyard manure and the commercial fertilizers ordinarily applied, is inadequate to the needs of plants, and until this is established the sweeping claims for the fertilizing value of soda which have appeared recently in the agricultural press must be looked upon as wholly unwarranted. These extravagant general claims for soda have not been made by the eminent European authorities above-mentioned but are to be accredited to parties who have entirely overlooked the fact that most of the experiments which they cite in substantiation of their claims were conducted with artificial or unusual soils, or else, as seems probable, this fact has been ignored for the reason that these soda advocates have had some personal and pecuniary interest in the development of a demand for soda for the purpose of finding an outlet for products in the sale of which they were interested. Such sweeping statements should be looked upon with suspicion unless they emanate from those who are employed in the search after truth for truth's sake, and who are not attempting thereby to further some personal financial ends. It has been in view of the apparently unwarranted and extravagant statements which have found their way into the agricultural press that this Station has felt impelled to submit the question of the manurial value of soda to a crucial test under such conditions as would be calculated to show its real agricultural value as a substitute for, and in connection with, potash. The principal experiment in this line which is being conducted at this Station comprises plots 1 to 48 of the so-called soda substitution experiment. The soil is naturally quite well provided with potash owing to its having been derived from granite, containing potash feldspar. Owing to this fact the experiment will probably have to be conducted for several years upon the same plots for the purpose of further exhausting the assimilable potash before an inefficiency of soda as compared with potash, if such exists, could be expected to become strikingly manifest. The first year of the experiment, 1894, no marked results were obtained except from those plots receiving potash and no soda and from those receiving soda and no potash. In that year nine different kinds of plants were grown upon these plots, and in 20 per cent. of the cases greater yields were obtained where soda was applied, and in 80 per cent. of the cases they were greater where potash was used. In 1895, which was the second year of the experiment, ten different kinds of plants were employed, and in 14 per cent. of the cases a greater yield was obtained from the soda plots, while in 86 per cent. of the cases the yield was greater from those which received potash. In order to render the relative action of the potash and soda as striking as possible, each plot received an equal amount of phosphoric acid, magnesia and nitrogen at the following rates per acre: Dissolved boneblack, 750 lbs., magnesium sulphate, 307 lbs., and dried blood, 1000 lbs. The full rations of potassium salts employed were such as would furnish exactly the same amounts of potassium per plot. The full ration of sodium carbonate was made such that it would neutralize the same amount of acid as the full ration of potassium carbonate, and then the quantity of common salt for the full ration was made such that it would furnish the same amount of sodium as the full ration of sodium carbonate. The following diagrams show the arrangement of the plots with the combinations of potash and soda applied and the relative positions of the various plants upon each plot:

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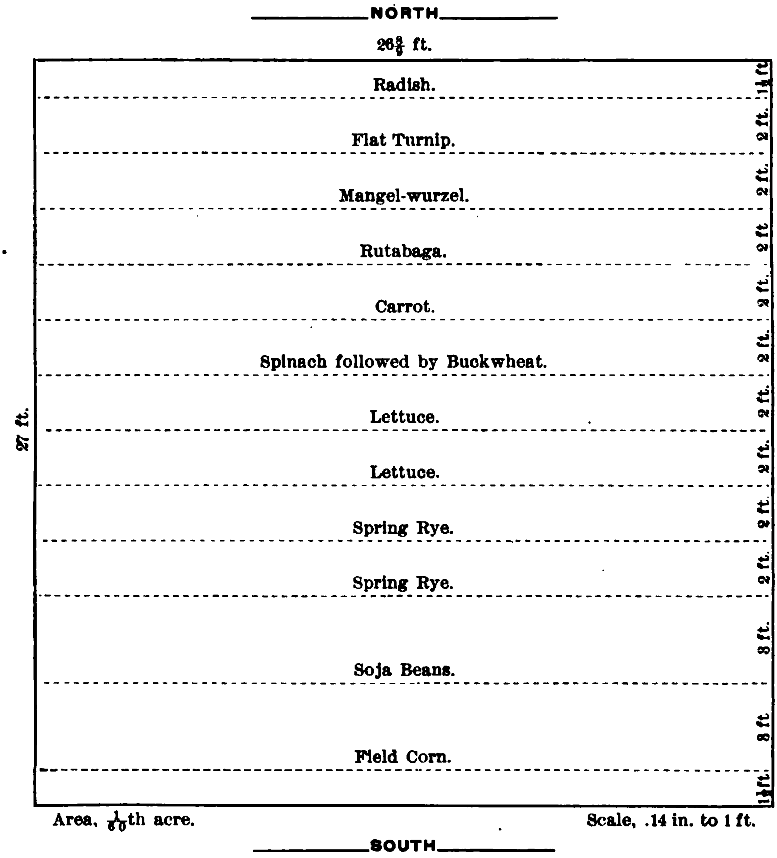
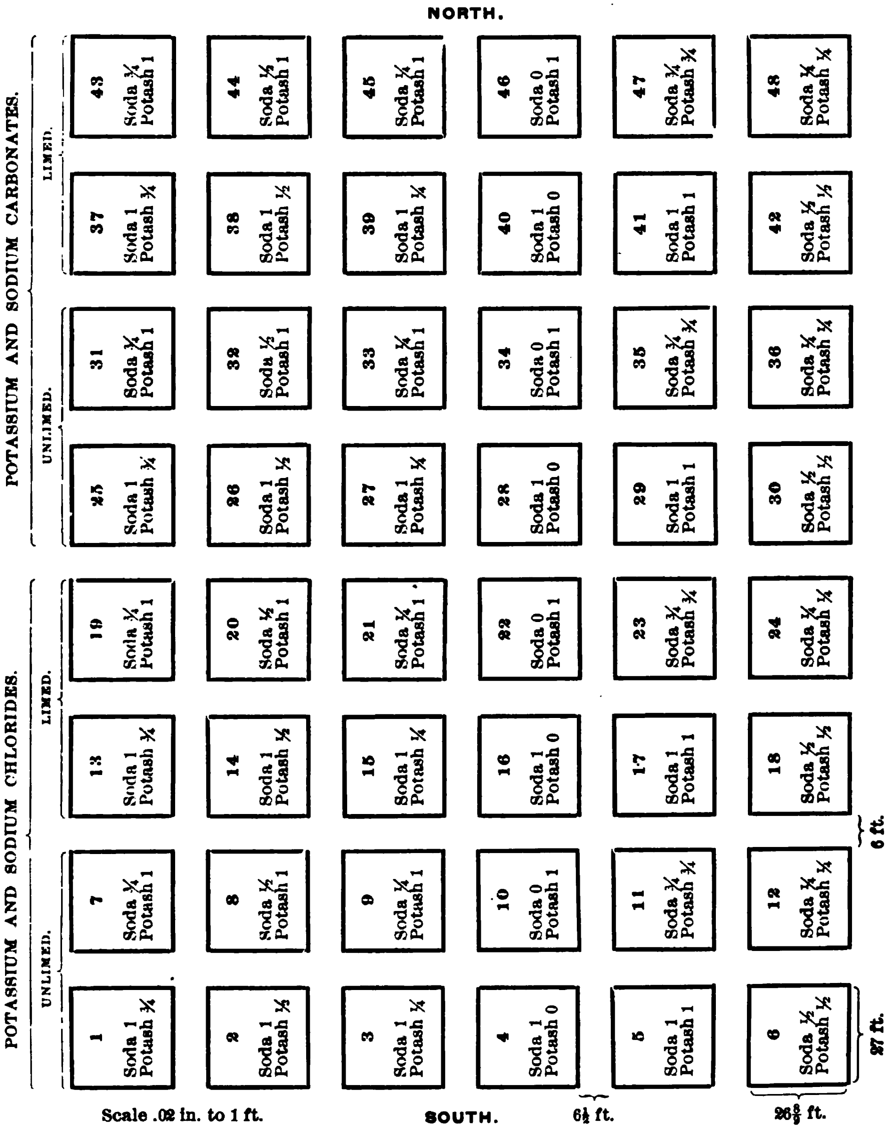
[1] Seventh Annual Report, R. I. Experiment Station, 1894, p. 168.



PLAN SHOWING THE ARRANGEMENT OF THE PLOTS AND THE KINDS OF FERTILIZING MATERIAL* APPLIED TO EACH.


NORTH.
SOUTH.
POTASSIUM AND SODIUM CARBONATES.
POTASSIUM AND SODIUM CHLORIDES.
LIMED.
UNLIMED.
6 ft.
27 ft.
6¼ ft.
26⅝ ft.

POTASSIUM AND SODIUM CARBONATES.	LIMED.	43 Soda ¾ Potash 1	44 Soda ½ Potash 1	45 Soda ¼ Potash 1	46 Soda 0 Potash 1	47 Soda ¾ Potash ¾	48 Soda ¼ Potash ¼
		37 Soda 1 Potash ¾	38 Soda 1 Potash ½	39 Soda 1 Potash ¼	40 Soda 1 Potash 0	41 Soda 1 Potash 1	42 Soda ½ Potash ½
	UNLIMED.	31 Soda ¾ Potash 1	32 Soda ½ Potash 1	33 Soda ¼ Potash 1	34 Soda 0 Potash 1	35 Soda ¾ Potash ¾	36 Soda ¼ Potash ¼
		25 Soda 1 Potash ¾	26 Soda 1 Potash ½	27 Soda 1 Potash ¼	28 Soda 1 Potash 0	29 Soda 1 Potash 1	30 Soda ½ Potash ½
POTASSIUM AND SODIUM CHLORIDES.	LIMED.	19 Soda ¾ Potash 1	20 Soda ½ Potash 1	21 Soda ¼ Potash 1	22 Soda 0 Potash 1	23 Soda ¾ Potash ¾	24 Soda ¼ Potash ¼
		13 Soda 1 Potash ¾	14 Soda 1 Potash ½	15 Soda 1 Potash ¼	16 Soda 1 Potash 0	17 Soda 1 Potash 1	18 Soda ½ Potash ½
	UNLIMED.	7 Soda ¾ Potash 1	8 Soda ½ Potash 1	9 Soda ¼ Potash 1	10 Soda 0 Potash 1	11 Soda ¾ Potash ¾	12 Soda ¼ Potash ¼
		1 Soda 1 Potash ¾	2 Soda 1 Potash ½	3 Soda 1 Potash ¼	4 Soda 1 Potash 0	5 Soda 1 Potash 1	6 Soda ½ Potash ½

Scale .02 in. to 1 ft.

NOTE.—The figures following the words "Potash" and "Soda" show whether the maximum amount or some fraction thereof was used.

* In addition to the above, each plot (one-sixtieth acre) received—dissolved boneblack, 12½ lbs.; dried blood, 16⅔ lbs.; and magnesium sulphate (epsom salts), 5.12 lbs.

It will be seen from the above that magnesium in the form of magnesium sulphate was applied to each plot in 1895. This was done in order that a supply of magnesia in assimilable form might be at the disposition of the plants. This seemed to be necessary for the reason that one of the benefits derived from sodium compounds is said to be their liberation of magnesia within the soil, and if, after the artificial application of magnesia, soda was still found to exert a beneficial effect, it could not be attributed to this indirect action but rather to its function as a direct fertilizer.

In 1894 plots 13 to 24 inclusive and also plots 37 to 48 inclusive received air-slacked lime at the rate of two tons per acre.

Under this arrangement it will be seen that all of the plots received applications of phosphoric acid and magnesia, while one-half of them were well supplied with lime; and since it is claimed that soda may have a beneficial action by virtue of its liberating lime, phosphoric acid or magnesia, it will be seen that on one-half of the plots any benefit which might be observed could not reasonably be explained upon such grounds, while upon the half which received no lime, a beneficial effect of the soda might be attributable to a direct fertilizing action or to the liberation of lime, or a combination of both. In 1894 and 1895 the neutralizing power of the carbonate of potash and of soda was determined, and such amounts were applied that a like degree of acidity or alkalinity might be maintained on each of the plots which were to be compared directly. This precaution seems to be absolutely necessary in an experiment of this character, for in the numerous experiments already conducted at this Station the condition of the soil as regards alkalinity or acidity seems to play an important part in the growth of plants even aside from its effect in connection with the process of nitrification. We are well aware that this point has been ignored except in the case of water cultures and swamp or muck soils by a large number of agricultural investigators, but we are nevertheless of the opinion that it is an important factor in the growth of plants upon agricultural soils, and that if it were left out of consideration in an experiment of this kind the conclusion might be drawn that soda had exerted a direct manurial action, when its beneficial effects were due solely to its having reduced the natural acidity of the soil. The table which follows gives the weights of the crops obtained upon the various plots.[1]

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[1] The corresponding results for the year 1894 may be found in the 7th Annual Report of this Station, pp. 179, 180.

SHOWING YIELDS, IN POUNDS, OF VARIOUS PLANTS, WHERE POTASH AND SODA WERE USED SEPARATELY AND COMBINED IN VARIOUS PROPORTIONS.

	SODIUM CHLORIDE AND POTASSIUM CHLORIDE.																							
	UNLIMED.												LIMED.											
Soda Ration	1	¾	1	½	1	¼	1	0	1	¾	½	¼	1	¾	1	½	1	¼	1	0	1	¾	½	¼
Potash Ration	¾	1	½	1	¼	1	0	1	1	¾	½	¼	¾	1	½	1	¼	1	0	1	1	¾	½	¼
PLOT No.	1	7	2	8	3	9	4	10	5	11	6	12	13	19	14	20	15	21	16	22	17	23	18	24
Radish	26.10	39.05	39.80	49.70	35.15	38.00	23.85	42.75	35.70	44.00	29.15	28.75	41.30	32.50	36.80	27.70	39.55	26.00	34.26	28.40	29.95	17.10	35.65	23.30
Flat Turnip	28.00	28.45	44.10	30.40	46.10	42.20	34.10	37.25	48.30	37.20	25.90	32.90	55.15	51.70	34.15	43.50	49.00	32.80	24.00	40.45	42.80	45.50	43.55	29.95
Mangel-wurzel	0	T.†	0.05	0.05	0.05	0	0	T.	0.15	0	0.15	0.25	4.55	4.00	9.60	8.60	11.50	8.55	5.60	13.75	16.00	6.15	22.85	4.65
Rutabaga	62.35	59.00	77.35	72.20	64.40	66.85	51.45	62.90	25.25	56.70	21.75	56.00	85.95	84.95	95.25	51.55	83.45	46.20	54.15	60.85	84.30	53.85	47.55	32.30
Carrot	2.25	3.85	8.15	3.50	9.15	6.35	5.60	10.00	6.20	3.85	33.20	8.30	15.35	21.20	8.55	27.30	5.85	12.35	1.05	11.15	2.05	17.50	1.30	21.35
Spinach	T.	0.05	0.25	0.25	0.15	0.25	T.	0.05	T.	T.	0.15	T.	0.25	0.80	0.45	0.15	0.45	0.70	T.	0.05	0.85	0.70	0.30	0.90
Buckwheat	22.80	25.15	27.00	29.80	24.40	31.75	28.75	23.95	27.50	28.50	28.75	27.20	27.10	27.15	36.20	28.80	25.10	36.05	26.85	29.55	28.10	32.80	27.95	28.00
Lettuce	0.35	0.58	0.95	2.70	0.25	0.25	0.03	0.05	0.00	0.13	0.80	0.38	0.35	2.70	1.80	2.98	1.85	0.73	0.18	1.80	0.40	0.35	0.33	0.10
Spring Rye	4.95	4.50	5.60	5.30	5.00	5.80	3.55	5.10	4.15	6.00	5.00	5.05	5.10	4.40	4.35	3.85	2.85	4.60	3.40	3.75	5.10	3.50	5.70	4.10
Spring Rye, air-dried	1.67	1.56	1.28	1.33	1.56	1.77	1.26	1.37	1.61	1.71	1.26	1.53	1.50	1.29	1.62	1.79	1.56	1.58	1.18	1.34	1.66	1.25	1.51	1.36
Soja Beans	6.10	6.15	6.05	7.75	5.80	7.10	*0.00	8.20	0.00	0.00	0.00	0.00	8.45	9.90	9.30	10.00	7.65	10.00	6.60	8.65	8.30	8.95	7.60	5.95
Soja Beans....beans.	2.85	4.00	3.10	2.95	2.80	3.25	0.00	3.80	0.00	0.00	0.00	0.00	4.00	4.50	4.30	4.75	3.55	4.85	3.00	4.15	4.00	4.20	3.85	3.10
Field Corn	30.15	24.90	24.75	29.00	25.75	35.15	24.25	26.55	29.05	33.75	32.75	29.65	34.10	36.25	32.85	44.30	32.55	39.20	20.90	42.45	38.70	41.55	32.30	29.60
Field Corn......ears.	12.15	10.70	10.60	11.25	9.90	12.80	12.05	11.50	12.10	13.67	13.70	12.75	13.90	13.45	14.50	15.70	13.30	14.90	9.70	16.35	15.10	13.55	12.65	12.65

* Woodchucks destroyed the soja beans on plots 4, 5, 6, 11, 12.

† T. indicates that a few small plants were visible, but not a sufficient quantity to register on scales.

SHOWING YIELDS, IN POUNDS, OF VARIOUS PLANTS, WHERE POTASH AND SODA WERE USED SEPARATELY AND COMBINED IN VARIOUS PROPORTIONS.

SODIUM CARBONATE AND POTASSIUM CARBONATE.

	UNLIMED.												LIMED.											
Soda Ration..........	1	¾	1	½	1	¼	1	0	1	¾	½	¼	1	¾	1	½	1	¼	1	0	1	¾	½	¼
Potash Ration........	¾	1	½	1	¼	1	0	1	1	¾	½	¼	¾	1	½	1	¼	1	0	1	1	¾	½	¼
PLOT No............	25	31	26	32	27	33	28	34	29	35	30	36	37	43	38	44	39	45	40	46	41	47	42	48
Radish	36.55	43.60	23.70	41.45	35.90	14.60	15.20	32.90	35.35	24.40	30.70	33.85	15.20	16.30	27.40	26.15	25.20	16.40	22.40	19.00	30.00	20.10	30.60	24.80
Flat Turnip..........	32.15	32.25	19.65	34.70	30.20	39.95	22.80	33.10	50.75	49.90	51.90	49.55	28.50	46.35	39.70	31.20	31.40	26.85	20.40	40.40	29.40	42.40	38.00	49.35
Mangel-wurzel.......	0.70	2.20	0.90	4.00	0.15	2.30	0.05	0.50	4.00	1.85	0.65	0.25	12.40	7.90	23.50	17.00	30.20	10.60	9.10	19.70	20.50	23.75	12.65	8.65
Rutabaga	62.85	71.55	72.55	75.80	65.25	62.45	51.60	58.90	84.10	84.90	76.65	74.85	69.10	90.55	92.00	89.80	70.90	67.95	26.20	57.70	66.20	70.20	53.00	65.65
Carrot................	8.10	19.45	10.50	13.85	19.60	5.00	3.65	10.55	24.00	11.75	14.10	6.85	24.90	11.50	15.85	18.05	23.55	15.00	17.20	27.75	30.35	26.55	27.00	11.20
Spinach	0.05	0.05	0.25	T.	T.	T.	T.	0.05	0.01	T.	0.05	T.	0.70	3.90	0.60	2.90	1.00	2.50	0.40	2.75	1.30	3.05	1.25	1.35
Buckwheat...........	27.70	31.15	28.20	31.80	25.90	31.45	17.15	32.55	24.00	25.60	28.15	25.40	33.95	30.90	30.95	26.35	34.15	27.30	30.90	20.50	30.65	21.55	28.95	26.45
Lettuce	3.75	1.75	4.60	1.50	2.05	1.73	0.25	2.10	0.25	3.28	1.03	0.12	8.55	14.38	5.40	16.25	5.78	13.03	4.88	15.23	10.15	14.53	6.93	11.13
Spring Rye...........	3.20	3.35	3.80	5.15	3.30	3.55	2.10	3.85	2.30	3.05	3.25	3.70	4.10	4.30	3.85	3.75	3.95	4.00	3.10	3.85	3.65	4.20	3.30	3.85
Spring Rye, air-dried	1.43	1.15	1.75	1.44	1.64	1.26	1.07	0.99	1.38	1.26	1.28	1.52	1.21	1.27	1.52	1.47	1.38	1.45	1.49	1.16	1.40	1.14	1.24	1.43
Soja Beans	8.60	8.45	9.65	8.30	8.45	7.50	7.40	7.95	9.05	5.70	6.65	8.70	11.60	10.55	11.50	11.10	9.00	10.35	9.55	9.30	8.60	8.95	8.00	9.20
Soja Beans....beans.	4.40	4.10	4.65	3.95	4.25	3.75	3.70	3.80	4.10	3.25	3.45	4.15	5.20	4.90	5.20	5.00	4.55	4.90	4.80	4.45	4.50	4.30	3.75	4.10
Field Corn...........	34.80	31.35	31.95	31.55	32.30	30.25	21.95	27.35	30.15	24.80	33.20	32.40	34.45	28.30	36.75	37.75	35.75	34.70	36.35	31.55	28.85	26.20	30.65	27.60
Field Corn......ears.	13.65	10.90	11.95	12.05	13.10	11.60	10.80	11.80	12.15	10.70	12.70	12.55	12.15	12.50	14.00	15.00	15.60	13.15	13.05	13.50	10.55	11.15	12.10	11.85

From an inspection of the foregoing tables it will be seen that no regular rate of increase in the crop is visible, either where increasing amounts of soda have been used in connection with a constant quantity of potash, or where increasing amounts of potash have been used with a constant quantity of soda. Indeed such regularity could not be expected at present owing to slight unavoidable inequalities in the plots which must have existed at the outstart, yet the differences due to the fertilizers applied would be expected to become more manifest from year to year as the experiment progresses. Even though such uniformity does not exist as could be wished, it will be seen by a careful inspection of the tables that the results are in accord with those secured in 1894, to the effect that, where potash in increasing quantities was added to a full ration of soda the yields were generally increased though not always in a uniform degree according to the amount of potash added. On the other hand, where soda in increasing quantities was added to a full ration of potash, the results were generally less satisfactory. In order to facilitate the comparison of the yields from soda without potash with those obtained from potash without soda the data bearing strictly upon this point have been extracted from the preceding tables and combined in the short table which follows.

SHOWING COMPARISON OF YIELDS, BY THE USE OF SODA AND OF POTASH, UPON LIMED AND UNLIMED PLOTS.

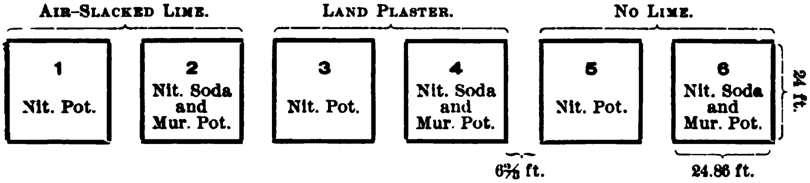
	CHLORIDES.				CARBONATES.			
	UNLIMED.		LIMED.		UNLIMED.		LIMED.	
	Soda.	Potash.	Soda.	Potash.	Soda.	Potash.	Soda.	Potash.
PLOT No.	4	10	16	22	28	34	40	46
Radish	23.85	42.75	34.26	23.40	15.20	32.90	22.40	19.00
Flat Turnips	34.10	37.25	24.00	40.45	22.80	33.10	20.40	40.40
Mangel-wurzel	0.00	trace	5.60	13.75	0.05	0.50	9.10	19.70
Rutabaga	51.45	62.90	54.15	60.85	51.60	58.90	26.20	57.70
Carrot	5.60	10.00	1.05	11.15	3.65	10.55	17.20	27.75
Spinach	trace	0.05	trace	0.05	trace	0.05	0.40	2.75
Buckwheat	28.75	23.95	26.85	29.55	17.15	32.55	30.90	20.50
Lettuce	0.03	0.05	0.18	1.80	0.25	2.10	4.88	15.23
Spring Rye	3.55	5.10	3.40	3.75	2.10	3.85	3.10	3.85
Soja Beans	*	8.20	6.60	8.65	7.40	7.95	9.55	9.30
Soja Beans.........beans.	*	3.80	3.00	4.15	3.70	3.80	4.80	4.45
Field Corn	24.25	26.55	20.90	42.45	21.95	27.85	36.85	31.55
Field Corn...........ears.	12.05	11.50	9.70	16.85	10.80	11.80	13.05	13.50

* Destroyed by woodchucks.

From the foregoing table it will be seen that with few exceptions a much smaller yield has been obtained from the soda than from the potash, and whether soda has been of any advantage or not in connection with the potash can probably only be determined, as stated in last year's report, by continuing the experiment for a number of years. Mangel wurzels and lettuce appear to have done better upon the plots where the carbonates of soda and potash were applied than where the chlorides of the same were used, yet the differences are slight, a condition which would be expected even if their neutralizing action were of particular value, owing to the small quantities of the carbonates used. In fact, in pot experiments with similar soil conditions where the quantities of carbonate of potash and of soda were about equal to those employed in this experiment, but little benefit, attributable to their neutralizing action, has been observed from their application, yet where 900 lbs. of carbonate of soda were used per acre in each of two annual applications most gratifying results have been obtained in connection with the growth of spinach and lettuce. A large application will therefore show its influence in a decided manner, and it remains to be seen if the cumulative effect of several small applications will be the same.

TEST OF THE EFFECTIVENESS OF SODA BY A COMPARISON OF THE YIELDS OBTAINED FROM NITRATE OF POTASH, AND FROM MURIATE OF POTASH IN CONNECTION WITH NITRATE OF SODA.

In the experiment with sodium salts previously outlined, a trial was made of the relative effectiveness of chlorides of potassium and sodium, and of the carbonates of the same. Since nitrate of soda is an ingredient of most commercial fertilizers, and because special claims have been made for the fertilizing value of the soda which it contained, it has been thought desirable to compare its action with that of nitrate of potash. In order to do this upon a proper basis, it was necessary to use an amount of nitrate of soda which would furnish an amount of nitrogen exactly equal to that contained in the nitrate of potash, and also to use a quantity of potash in connection with the nitrate of soda which would be identical with that contained in the nitrate of potash. As a source of potash for this purpose the muriate of potash was employed. The experiment was also so arranged that comparisons as above mentioned could be made upon unlimed plots, upon those which had received land plaster (gypsum) and air-slacked lime, as shown in the following diagram:



In order to preclude the possibility of any benefit being derived from the soda by its indirect action in liberating phosphoric acid and magnesia, a liberal application of both of these ingredients was made to each plot. As will be seen from what has preceded, an equal amount of nitrogen, phosphoric acid, potash and magnesia was applied to each plot, and certain of the plots received in addition air-slacked lime or land plaster, and it should be stated here that the amount of land plaster employed was such as to furnish lime (CaO) at exactly the same rate per plot as the air-slacked lime. It should also be noted that muriate of potash contains large quantities of chlorine, so that the plots to which it was applied received in addition to what was used upon the nitrate of potash plots both soda and chlorine. The various fertilizing ingredients above mentioned were applied at the following rates per acre and thoroughly harrowed in: dissolved boneblack, 800 lbs.; magnesia, in form of magnesium sulphate (epsom salts), 400 lbs.; muriate of potash, 474 lbs.; nitrate of soda, 386 lbs.; air-slacked lime, 5,000 lbs.; land plaster (gypsum), 9,805.8 lbs.

Stützer[1] has given a tabulated summary of experiments with sulphate of ammonia and nitrate of soda, from which it is seen that the yields from the latter were generally greater though like amounts of nitrogen in the respective forms were used. It will be seen, however, from a careful study of these results that the yield of beets was proportionately much greater from nitrate of soda than were those obtained from other crops, and Wagner and Dorsch[2] cite these results in support of their claims for the direct fertilizing function of soda. We have observed, however, that nitrogen in the form of nitrate of soda has proved more efficient than that in form of sulphate of ammonia, and the circumstances under which the observations were made preclude the explanation of the difference upon the grounds brought forward by Wagner and Dorsch. In our experiments the results seem to have been due to incomplete nitrification of the sulphate of ammonia, which appeared to be caused by the existing acidity of the soil. In view of the fact that applications of sulphate of ammonia would tend to make the soil more acid than before, while nitrate of soda would not, it appears probable that some of the observed differences in the effectiveness of the two compounds might have been due in some measure to their effect upon the soil, so far as concerns its acidity or alkalinity. Our own experiments upon sour upland soil, as well as the observations of others particularly upon sour and neutral muck and peat, show conclusively that the above mentioned soil condition is a most important factor in connection with the growth of plants, and beets have been shown to be particularly injured upon an acid soil where certain other cultivated plants make an ideal growth. In certain experiments which we have conducted for another purpose, sulphate of ammonia proved decidedly less efficient than nitrate of soda in the growth of beets, even where large applications of air-slacked lime were made in connection with each; yet even here it did not seem justifiable to conclude, as others might have done, that the observed difference was due solely to a direct manurial value of the soda, and in view of the fact that the continued application of the sulphate of ammonia might have effected a decided difference in the acidity of the two plots, it seemed desirable to obtain further data from an experiment in which nitrogen in the form of nitrates was employed in each case, and in which sulphuric acid would not enter as a residual product; and particularly where sulphate of ammonia, if this salt as such is in any case injurious to plants, would be entirely eliminated. Nitrates of ammonia, lime, magnesia, and potash suggested themselves as materials which might be used for this purpose in comparison with nitrate of soda.

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[1] Der Chilisalpeter, Berlin, 1886, p. 98.

[2] Die Stickstoffdüngung, Berlin, 1892, pp. 238–242.

Yet for various reasons which it is perhaps unnecessary to enumerate here, nitrate of potash was finally selected. Even by its use it became necessary, in order to keep the amount of potash employed in both cases constant, to supplement the nitrate of soda with potash in some form. For this purpose the chloride or muriate of potash was, for various reasons, finally selected. The following table shows the results secured in this experiment with two varieties of beets:

KIND OF CROP.	UNLIMED.		LAND PLASTER. (Gypsum).		AIR-SLACKED LIME.	
	Muriate of Potash and Nitrate of Soda.	Nitrate of Potash.	Muriate of Potash and Nitrate of Soda.	Nitrate of Potash.	Muriate of Potash and Nitrate of Soda.	Nitrate of Potash.
	Plot No. 6.	Plot No. 5.	Plot No. 4.	Plot No. 3.	Plot No. 2.	Plot No. 1.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Sugar Beets........................**roots**....	4.5	6.3	66.5	95.0	204.5	174.0
Sugar Beets........................**tops**.....	5.3	8.0	75.0	85.5	168.5	125.5
Red Table Beets (Bastians)........**roots**....	14.0	9.5	114.5	129.0	228.5	202.5
Red Table Beets (Bastians)........**tops**.....	11.0	10.0	52.5	88.5	68.5	78.5

It is hoped that it will be possible to continue this experiment for several years, and the results above given are introduced in this connection, at this time, for the reason that they may be put permanently on record, and not because it is considered that they furnish a sufficient basis for the drawing of final conclusions. It will be seen from an inspection of the above table that upon the plots which received air-slacked lime, the yields were greater from the muriate of potash and the nitrate of soda than from a like amount of nitrogen and potash in the form of nitrate of potash. In connection with the land plaster, or gypsum, however, the reverse was true. It is possible that these results are only incidental and that they may not repeat themselves upon a continuation of the experiment. If they are not incidental, several reasons might be assigned for the differences observed. It might be claimed that the amount of potash supplied was inadequate to the needs of the plant, and that upon the plots that received air-slacked lime the soda of the nitrate of soda had been used by the plant to supplement the potash, whereby the yields were increased. Where land plaster, or gypsum, was employed, it will be seen that the yield in both cases was greater on the nitrate of potash plot than upon that which received muriate of potash and nitrate of soda. If the basis for the explanation of the higher results with muriate of potash and nitrate of soda upon the air-slacked lime plots is the correct one, it might be argued that corresponding results should have been obtained in connection with land plaster, or gypsum. It is, however, generally stated that land plaster is better able than air-slacked lime to liberate potash within the soil, and upon such a basis, if other important factors did not enter into consideration, it would be expected that the yield from the plots which received land plaster would be greater than from those that received air-slacked lime, which, as will be seen, was not the case. It cannot be argued that the greater yield from the nitrate of potash as compared with the muriate of potash and the nitrate of soda where land plaster was employed, was due to the liberation of more potash in the former than in the latter case, for like quantities of plaster were employed in each case, and consequently it would have been expected that so far as the action of the plaster was concerned, like quantities of potash would have been liberated, and furthermore one of the functions invariably ascribed to soda is the liberation of potash, and had the soda been of any particular benefit in this connection, the results secured would have been expected to be the opposite of those obtained. It is possible, however, that the less satisfactory results obtained from the muriate of potash and the nitrate of soda as compared with the nitrate of potash on the plots that received land plaster, may have been due to an injurious action of the chlorine of the muriate of potash, which, in connection with the plots which received air-slacked lime, may have been counteracted by lime in this particular form.

The yields upon the unlimed plots were extremely slight for the reason that most of the plants died while they were still young, while those which survived throughout the season failed, owing to the soil condition, to make much growth. Owing to this fact the results obtained upon the unlimed plots have, so far as concerns the fertilizing value of soda, no particular significance.

SUMMARY.

The results of the first of the preceding experiments have shown in 1895 even more conclusively than in 1894, that applications of soda without potash have been upon our soil, far less beneficial than applications of potash without soda. The indications of this season's results, like those of 1894, are to the effect that increasing quantities of potash when applied in connection with a given amount of soda, show a greater benefit than increasing quantities of soda applied in connection with a given amount of potash. In the case of mangel wurzels and lettuce a slightly greater advantage seems to have been derived from the use of the carbonates of potash and of soda, than from the chlorides of the same, a difference which there is every reason to believe would have been much greater had the applications of potash and soda been largely increased. Air-slacked lime as has been observed in other experiments has had a wonderfully beneficial effect in connection with certain plants, which has been attributed by us not only to its direct fertilizing action but also largely to its having overcome the acidity of the soil or to its having effected the decomposition of constituents of the same which exerted an injurious influence upon the growth of certain plants.

THE RECOGNITION OF THE ACIDITY OF UPLAND SOILS AND ITS BEARING UPON AGRICULTURAL PRACTICE.

H. J. WHEELER, B. L. HARTWELL AND G. M. TUCKER.

So far as we have been able to ascertain no one in this country has thus far definitely called attention to the existence of an injurious degree of acidity in upland or naturally well-drained soils, and at the same time pointed out a simple and practical means for its recognition. American agricultural chemists appear not only to have been of the opinion that an injurious degree of soil acidity is to be found only in muck and peat swamps and in spots where stagnant water occurs, but they make no mention of making tests for acidity as a means of recognizing a deficiency of carbonate of lime. In speaking of humous bodies in the soil, S. W. Johnson[1] states that they are "for the most part acids, but they do not exist to much extent in the free state, except in bogs and morasses. A soil that is fit for agricultural purposes contains little or no free acid, except carbonic acid, and sometimes gives an alkaline reaction with test papers." Storer,[2] in his work on agriculture speaks of sour meadows and the use of lime in correcting their acidity, but he leaves the reader in doubt as to whether the meadows referred to were wet or naturally well-drained uplands. The impression which we have obtained has been to the effect that the allusion was to wet meadows, for had such not been the case it would seem probable that he would have called attention to the necessity for acid tests in upland or well-drained soils, which we do not find that he has done. Jackson,[1] in connection with his geological survey of the State of Rhode Island, examined the soil of a farm[2] situated two miles north of the city of Providence and in speaking of the practice of the owner in manuring, states that "By chemical analysis of the natural soil, it was found to be an ancient granite diluvium, charged with decomposed vegetable matters in an acid state. Hence the theory of his improvements, by means of ashes, containing alkaline matter and lime." Ruffin,[3] in his extensive work on calcareous manures made almost constant reference to the acidity of certain Virginian soils which were unquestionably such as would be called upland and naturally well-drained ones. From a careful study of his writings it appears that the acidity of the soils in question was concluded rather than definitely proved. His argument was to the effect that soils which contained carbonate of lime could not be acid and he employed for the purpose of recognizing the presence or absence of carbonate of lime a method[4] proposed by Davy. By this method carbonate of lime if present in considerable quantity could be readily detected, yet it was probably not sufficiently delicate for the recognition of very small quantities of this compound, so that a soil which by this means may have been found to contain no carbonate of lime may nevertheless have contained a slight amount, which, according to E. W. Hilgard,[5] may have been sufficient, for he states that "all the advantages of calcareous soils are secured with percentages of lime far below those in which the slightest effervescence can be perceived." Ruffin further supports his view by citing the fact that pines and sorrel, which he said contained acids, grew luxuriantly upon the land before liming but tended to disappear afterward, while other plants which heretofore were to be found growing naturally only upon soil which contained carbonate of lime grew well upon the so-called acid land after liming. We do not question the fact that many if not all of the soils referred to by Ruffin as acid may have been so,[1] but merely call attention to the fact that direct testimony to that effect was lacking, a point which Ruffin himself recognized and deplored, but which he stated he had no doubt some chemist at a later date, with the help of the accumulated knowledge of the future would be fully able to demonstrate. In the course of Ruffin's experiments he employed carbonate of lime in the form of marl. He states that this material contained as a rule from 30 to 50 per cent. of carbonate of lime and practically no other ingredients of fertilizing value. It is possible that small quantities of potash and phosphoric acid were also present, but it would not seem reasonable to attribute all of the benefits noticed to the possible presence of these ingredients. E. W. Hilgard,[2] in the course of his work upon the soils of the Southern States, particularly in connection with the sandy pine lands of Mississippi, has called attention to their need of lime, though we find no mention of tests for acidity having been made in connection therewith; he states, however, in a private communication, that the recognition of their acidity was what led to his recommendation of the application of this substance. He furthermore says "you are doubtless right in thinking that attention should be more definitely called to the importance of soil acidity as an unfavorable agent in agriculture outside of swamp or marsh lands." A. Vœlcker[3] says that "There is a ready test for ascertaining whether a soil is likely to contain an injurious constituent. All that is necessary is to put a strip of litmus in contact with wet soil; if the blue color of the test paper turns rapidly red, the soil is certain to contain something injurious to plant life." The soils which he appears particularly to have examined were reclaimed marshes or muck, etc., or what would be termed unusual soils. Several French writers[1] refer to the acid soils of Brittany, Limousin, and other sections, which in many instances have been wonderfully benefited by the use of lime. Many of the soils referred to appear to have been upland or well-drained. Schultz-Lupitz,[2] in speaking of the sandy soil of his section in Germany, refers to its being poor in lime and therefore becoming sour and unfit for the economical production of plants; he makes, however, no reference to the use of litmus paper nor of any other means of definitely ascertaining its acidity, but appears to infer that it was acid from the beneficial action of lime upon it. E. W. Hilgard says,[3] "'saurer Sandboden'[4] is the expression I have frequently heard applied in Berlin to the uplands of that region and the Mark Brandenburg at large." W. Detmer[5] states distinctly that not all soils which are excessively rich in humus are acid, and on the contrary that sandy soils sometimes give an acid reaction; and he mentions in the same connection the value of the litmus paper test as an indicator of this condition. Th. Hübener[6] likewise calls attention to the frequent acidity of sandy soils.

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[1] How Crops Feed, p. 229.

[2] Agriculture, Vol. II, pp. 148-149.

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[1] Report on the Geological and Agricultural Survey of the State of Rhode Island, Providence, 1840, pp. 268-269.

[2] A sample of soil from this farm has been tested recently and found to quickly redden blue litmus paper.

[3] An Essay on Calcareous Manures, Richmond, Va., 1853, Fifth Edition.

[4] Ruffin's Calcareous Manures, Richmond, Va., 1853, p. 58.

[5] Jour. American Chemical Soc., Vol. XVI, No. 1, 1894, p. 43.

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[1] Thus far we have not obtained any soil from the vicinity referred to, but through the kindness of Dr. O. C. Wiggin we have obtained upland soil from Keysville, Va., which gives a decided acid reaction.

[2] Tenth United States Census.

[3] Journal Royal Agricultural Society, England, 1865, p. 115.

THE EFFECT OF ACIDITY UPON THE GROWTH OF PLANTS.

S. W. Johnson[7] states that "A soil that is fit for agricultural purposes contains little or no free acid, except carbonic acid, and oftentimes gives an alkaline reaction with test papers," while Storer[8] asserts that "Cultivated soils, though sometimes neutral to test papers, as a rule exhibit a faint acid reaction; and experience with water culture has shown that slightly acid solutions are favorable for the growth of plants. But any excess of soluble acids in the soil would be highly detrimental." Jas. F. W. Johnston[1] in speaking of soils which are moist and where much vegetable matter abounds, says that "The effect of this superabundance of acid matter is, on the one hand, to arrest the further natural decay of the organic matter, and, on the other, to render the soil unfavorable to the healthy growth of young or tender plants." Vœlcker[2] says regarding the action of soil upon litmus paper, "if the blue color of the test paper turns rapidly red, the soil is certain to contain something injurious to plant life. All good and fertile soils either have no effect upon red or blue litmus paper, or show a slight alkaline reaction; that is to say, in a wet condition they restore the blue color to reddened litmus paper." A. Mayer[3] states that the so-called sour humus is really somewhat sour, and that on this account it is, without doubt, injurious to plants. Shultz-Lupitz, as heretofore cited, speaks of sandy soils becoming sour and unfit for the profitable production of plants. Mulder[4] claims that "a good soil should turn a red litmus paper blue," (that is, it should be alkaline and not acid). A. Stutzer[5] says that "a large amount of acid in soils is injurious to all cultivated plants." Th. Hübener[6] states that "hardly anything has so great an influence upon the character of the vegetation as the condition of the humus." In this respect plants may be divided into three classes, one which thrives best where the humus is sour, another which refuses to grow where sour humus is present, and a third and the largest class, the individuals of which can accommodate themselves to either condition; and also that where a soil is recognized by means of litmus paper as being sour the acidity must be overcome by the use of marl or lime.

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[1] See particularly Müntz and Girard, Les Engrais, Tome 3, Paris, 1891, pp. 190-191.

[2] Die Kalidüngung auf leichtem Boden, Berlin, 1890, S. 25.

[3] Quoted from a private communication by permission.

[4] Sour sandy soil.

[5] Die landw. Versuchs-Stationen, 14, S. 277.

[6] Schulze's Lehrbuch der Chemie für Landwirthe, Vierte Auflage, S. 588.

[7] How Crops Feed, p. 229.

[8] Agriculture, Vol. II, p. 148.

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[1] Lectures on the application of Chemistry and Geology to Agriculture, New York, p. 403.

[2] A. Vœlcker, Jour. Royal Agricultural Society, England, 1865, p. 115.

[3] Lehrbuch der Agrikulturchemie, Heidelberg, 1886, S. 289.

[4] Chemie der Ackerkrume Bd. 1. S. 363-364.

[5] Leitfaden der Düngerlehre, Vierte Auflage, S. 78.

[6] Schulze's Lehrbuch der Chemie für Landwirthe, Vierte Auflage, S. 588-589.

THE DETECTION OF THE ACIDITY OF SOILS.

Certain soluble organic acids and compounds which give an acid reaction have from time to time been noted as constituents of certain soils, among which are formic and acetic acid and protosulphate of iron. In case a soil contains any considerable amount of these ingredients a watery extract of the same will readily impart to blue litmus paper a red color which persists after drying. Humic and other complex organic acids, and doubtless also various acid compounds of soils, are but slightly soluble in water, so that a soil may be decidedly acid and the fact possibly escape detection if the test is based wholly upon the reactions upon litmus solution and upon litmus paper obtainable solely by means of a watery extract.[1] In 1891, when the first tests for acidity were made in our soil, no specific directions for the carrying out of the litmus paper test had come to our notice, yet from trials made in various ways the most reliable and practical method seemed to be that of moistening the sample of soil sufficiently with distilled water so that it would have about the consistency of a thick paste. At this point the blue litmus paper was introduced into the soil, which was then pressed about the paper upon both sides. The acidity of the soil was recognized by the disappearance of the blue and the appearance of a red tint, which was more noticeable upon removing and rinsing the test paper with distilled water. More recently Schulze's[2] work, to which our attention has been kindly called by Prof. E. W. Hilgard, has come to hand, wherein it is stated that in making such a test the moistened soil should be pressed about the paper.

The question of the acidity of soil having forced itself upon our attention, on account of the acid character of much of the soil upon the Experiment Station farm, and in view of the widely differing character of plants so far as concerns the effect of acidity upon their growth, it seemed desirable to discover if possible some satisfactory means of determining the total relative acidity of soils; for it appeared probable that from such a test one would be better able to state what quantities of lime should be applied to certain lands for particular purposes, and also to state more definitely what plants would be expected to succeed best upon them. It must be obvious from what has been said concerning the insolubility of certain acid constituents of the soil, that a determination of the amount of acid in a watery extract of the same would fail utterly to indicate the degree of acidity which actually existed, and that a method of determination to yield satisfactory results, must take into account the more insoluble as well as the easily soluble acid constituents of the soil. In the course of the work which has been done in the Station laboratory in this line several methods of titration have been employed with varying degrees of success; a great difficulty in the way of which in many instances has been that of securing an indicator which would give satisfactory results. Owing to the difficulties met with, and for the purpose of obtaining results by more than one method, experiments were begun in April, 1895, with the intention of measuring if possible the relative acidity of soils by determining the amount of carbonic acid gas which they were capable of liberating from certain carbonates under various conditions. The work in this direction has not yet been completed. These investigations have been necessarily long delayed and dropped entirely at intervals owing to the pressure of routine work in the laboratory. Br. Tacke,[1] in connection with his work upon "moor" soils, mentions the fact that no method is known for determining their degree of acidity, and states that he has attempted to measure it by estimating the amount of carbonic acid expelled from carbonates under certain definite conditions. Apparently, therefore, we had, independently, attempted by similar means to determine the relative acidity of soils, though the soils under consideration were entirely different in character.

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[1] In view of the fact that our subsoil consists of sand and gravel thus furnishing good natural drainage, it would appear unreasonable to attribute the injurious property which it possesses to the presence therein of easily soluble compounds, for the heavy fall and spring rains would be expected to leach them away.

[2] Lehrbuch der Chemie für Landwirthe, Vierte Auflage, S. 587.

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[1] Chemiker-Zeitung, Jahrg. XIX, 95, Nov. 27, 1895, S. 2123.

R. Braungart[1] has given a most extensive digest of what has been written in relation to the plants which exist naturally upon soils of various kinds, from which, supplemented by his personal observations, he has been led to believe that the existence or absence of certain plants within given limitations as to temperature, etc., shows the preponderance or absence of certain mineral constituents in the soil. It is impossible here to give a complete summary of his conclusions, but it will suffice to state that he speaks of lime plants, which grow where the percentage of calcium carbonate is high, and others which are suited by lesser quantities, and also certain plants which are best suited by soils particularly poor in lime; and adds that in case of certain of these, two per cent. of lime in the soil is sufficient to render the existence of some of them impossible.[2] L. Von Wägner,[3] in a discussion of soils of various kinds, gives a long list of plants which are characteristic of those of various natures. In the experiments already conducted at this Station with about ninety varieties of plants, most wonderful differences in their ability to grow upon the soil before and after liming have been found to exist. Certain cultivated plants have been found to nearly or quite succumb until lime has been applied, after which they have made a magnificent growth; characteristic among these may be mentioned common red clover, spinach, lettuce, beets and timothy (*Phleum pratense*). Upon our soil when left to itself for some time, certain plants seem eventually to predominate, while others gradually disappear. Considering that the soil contains no carbonate of lime, to the absence of which, together with other basic compounds, its acidity is apparently due, it will be obvious in connection with what has been said above that the natural vegetation would be of a type suited to such a soil. Having observed therefore what plants thrive here naturally, the recognition of similar plants elsewhere would lead to the natural conclusion that there similar conditions may also exist. Those plants which have appeared particularly characteristic of acid soil in our immediate vicinity are the following: bird-foot violet (*Viola pedata L.*), wild or beard grass (*Andropogon scoparius Mx.*), species of St. John's wort (*Hypericum*), common or soft rush (*Juncus effusus L.*), wood rush (*Luzula campestris D. C.*), and several moses; the appearance of common sorrel (*Rumex acetosella, L.*), is common as soon as the soil is cultivated. In addition to one or two of the plants above mentioned, Ruffin speaks of the pine as a plant which thrives best upon soil poor in lime. Various French[1] and German writers state that clover fails to thrive upon land deficient in carbonate of lime, and as above stated we have found the same to be true of timothy; so that by observing not only those plants which thrive but also those which fail to thrive, indirect evidence of the needs of the soil may be, in a measure, afforded. In the course of observations upon the nature of the wild plants, cultivated grasses and clover, not only in many parts of Rhode Island but also in some parts of Massachusetts and Connecticut, the soil appears to be probably in somewhat the same condition as our own; quite marked changes in this respect are noticeable as one travels westward from Boston. At a distance of twenty or thirty miles clover and timothy are in certain sections found to largely disappear, and farmers in such sections have stated that clover cannot be made to grow and that timothy runs out quickly. In fact statements to the same effect have recently come to our notice from New York, Connecticut, and several of the eastern, seaboard States.

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[1] Jour. für Landw. 1879, S. 423 u. 481; ibid 1880, S. 59 u. 155.

[2] Ibid. 1880, S. 174.

[3] Landw. Pflanzen-Produktions-Lehre, Buda Pest, 1874, S. 79-103.

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[1] Müntz and Girard; Les Engrais, Tome 8, p. 190; also Dehérain; Traitè de Chimie Agricole 1892, p. 581.

SOME OBSERVATIONS RESPECTING THE RELIABILITY OF THE LITMUS PAPER TEST AS AN INDICATION OF INJURIOUS ACIDITY AND OF A LACK OF CALCIUM CARBONATE IN SOILS.

During the progress of our experiments the reliability of the litmus paper test has been questioned by certain agricultural chemists who have become interested in our work, though to our knowledge this has not been done publicly.

It is generally believed that carbonic acid plays a most important role in soils, by virtue of its solvent action upon various elements of plant food. It is understood likewise that it is ever present in soils since it is excreted by plant roots, is carried to the soil in the rain water, and is continually produced during the decomposition of the organic portions of the soil.

It is stated[1] that carbonic acid turns blue litmus wine red but that the blue color returns upon exposure. This statement evidently relates to litmus solution and not necessarily to litmus paper; however, Wahnschaffe[2] in speaking of the use of litmus paper for detecting the sour character of soil humus, states that since the free carbonic acid of the soil will redden the paper one must allow it to dry and see if the paper is still red. He adds that sour humous soils are especially injurious to plants. Having accepted the statements as made by Wahnschaffe as correct and that the reddening produced by free carbonic acid would disappear upon drying the test paper, we at first took the precaution to follow his directions and advised others to do so. Recently, however, upon the occasion of a visit to this Station, Dr. H. E. Stockbridge stated that he was quite sure that while in Japan at the Imperial College of Agriculture at Sapporo, he tested blue litmus paper with carbonic acid and found that the reddening which it produces is permanent and not temporary as indicated by Wahnschaffe. In view of this statement it became imperative to test the matter for ourselves. Accordingly carbonated water was prepared for the purpose as follows: Chemically pure sodium bicarbonate and distilled water were placed in an Erlenmeyer flask to which was attached a perpendicular condenser from the upper end of which a glass tube led to a wash bottle containing distilled water and another from this bottle to the glass flash in which the excess of carbon dioxid was finally collected in distilled water.

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[1] Watts' Dictionary of Chemistry, Vol. 1. p. 695.

[2] Anleitung z. wissens. Bodenuntersuchung, Berlin, 1887, S. 56.

The carbonate water thus prepared was tested upon commercial blue litmus paper. When one or two drops of this water was allowed to fall upon a large piece of blue litmus paper the characteristic wine red color appeared immediately, but upon allowing the litmus paper to dry naturally *in air not contaminated with ammonia* it was found to return gradually to its original blue color. It was found, however, that if an entire piece of litmus paper was acted upon by the carbonic acid the red color remained upon drying. This latter observation raised a suspicion that the distilled water might have contained traces of volatile acids derived by distillation from our well water, a suspicion which was strengthened by the well known occasional presence of volatile organic acids in soils. Accordingly the distilled water was tested and found to be neutral. A new lot of water was placed in the Erlenmeyer flask and after drawing the water from the condenser, steam was passed through the entire apparatus for some time to insure the removal of any possible volatile acids in the apparatus or water. The distillate accompanying the steam was neutral in its reaction. A new lot of sodium bicarbonate was now introduced into the distilled water remaining in the flask and thus a new lot of carbonated water prepared which gave results with litmus paper corresponding exactly with those first obtained. The fact that a piece of blue litmus paper when entirely reddened with carbonic acid does not return to its original color leads to the conclusion that this change of color where only a spot was acted upon was due to a slight alkalinity of the commercial litmus paper and to the diffusion of the alkali through the acid spot. Similar results secured with very dilute citric acid lead to the same conclusions. It will be evident, therefore, that Heinrich's[1] supposition that the return of the blue color when litmus paper has been reddened by pressing it between the roots of plants, was in and of itself a sufficient basis for the assertion that they excrete carbonic acid, may have been a mistake. From these results it appeared that free carbonic acid is capable of permanently reddening blue litmus paper provided no other factors enter into consideration. It is well known that if carbonated water acts upon sodium and potassium carbonate their corresponding bicarbonates are formed and that in solution there may be not only the carbonate and bicarbonate but also free carbonic acid and that notwithstanding the presence of the free acid the reaction of the solution will be alkaline. It is also well known that carbonic acid exerts a highly solvent action upon calcium carbonate as shown by the caverns formed in limestone by its means and by the accompanying stalactites and stalagmites. By this action of carbonic acid calcium bicarbonate is formed which is said to be alkaline in a less degree than the bicarbonates of sodium and potassium. The idea naturally suggested itself therefore of ascertaining if it were possible for the carbonic acid made as above described, to exert an acid action upon blue litmus paper so long as plenty of calcium carbonate was at hand to be acted upon for if such were not found to be the case it would seem improbable that the still weaker carbonic acid which occurs in soils, would, in presence of calcium carbonates give rise to an acid reaction. Accordingly four small Erlenmeyer flasks were prepared as follows: one with distilled water, one with carbonated water, one with distilled water and calcium carbonate and one with carbonated water and calcium carbonate. These were allowed to stand for twenty-four hours and the liquid was then tested with litmus solution which had been prepared according to third method given by Sutton.[2] At the end of the time the distilled water reacted neutral as it did before and the carbonated water was still strongly acid. The supernatant liquid from the distilled water and calcium carbonate was slightly though distinctly alkaline and that from the carbonated water and calcium carbonate was already strongly alkaline.

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[1] Beurteilung der Ackerkrume Wismar, 1882, S. 46.

[2] Handbook of Volumetric Analysis, London, 1882, p. 31.

To further test the matter four flasks like those above mentioned were prepared as follows: one with carbonated water, one with distilled water and soil, one with distilled water, calcium carbonate and soil, and one with carbonated water, calcium carbonate and soil. The soil employed gave an acid reaction with litmus paper and was from the farm of F. P. Babcock, of Westerly, R. I., upon which the experiment with beets and lime, mentioned elsewhere in this article, was conducted. Each lot was thoroughly shaken to insure a perfect mixture and the supernatant liquid tested as above after a subsidence of twenty-four hours. It was found that the carbonated water and the liquid from the distilled water and soil were acid (the latter slightly) and that from the distilled water and from the carbonated water to which both calcium carbonate and acid soil had been added were alkaline, the alkalinity of that from the carbonated water being greater than the other. The soil residues from the three flasks were now tested and found to correspond exactly with the reaction of the liquids. Even a red litmus paper was very quickly turned blue by the residue from the flask which received the carbonated water. The residues were subsequently extracted with water with one intermission for about twelve consecutive hours and upon examination were still found to react alkaline in both cases where the calcium carbonate was added. E. W. Hilgard, the leading authority on soils in this country, is a firm believer in the necessity of the presence in soils at all times of at least a small amount of calcium carbonate, though he believes that an amount less than sufficient to produce effervescence with acids will suffice. It would seem probable, therefore, that a soil to meet Prof. Hilgard's requirements even if it contained free carbonic acid would still contain sufficient calcium carbonate to prevent the development of any marked degree of acidity.

It should be mentioned that the color produced by carbonic acid upon blue litmus paper is, as before stated, a wine red and entirely unlike that produced by our acid soils. It appears from the foregoing in connection with the observation by Stöckhardt, mentioned elsewhere, that soils in which there is any considerable amount of calcium carbonate, well distributed, will not give an acid reaction with litmus paper and that the presence of carbonic acid would be more favorable to the production of an alkaline than to an acid reaction owing to its transforming and solvent action upon the calcium carbonate of the soil. What is said of calcium carbonate applies to magnesium carbonate as well. These results do not indicate that the subsequent drying of the litmus paper is a necessity, for first: if sufficient bases are present in the soil the reaction cannot be strongly acid and the presence of free carbonic acid in such quantities as are liable to be present would favor an alkaline rather than an acid condition if the soil is otherwise in proper condition. Second: carbonic acid appears to permanently redden blue litmus paper when thoroughly acted upon so that the subsequent drying of the test paper seems to be unnecessary.

SOME REASONS FOR THE ACIDITY OF SOILS.

Upon lands where nature is allowed to take her course there are reasons for supposing that the soil would become acid less rapidly than where certain chemical fertilizers are applied and where the crops are annually removed. In order to illustrate this point it becomes necessary to first touch upon the physiological processes by which the plant obtains its mineral ingredients, and also the chemical changes likely to occur as a result particularly of the application of mineral fertilizers. So far as we have referred to the work of authorities on plant physiology, they seem to agree that plants may take up a limited amount of substances which they do not require. Such elements do not, however, usually accumulate in plants beyond a moderate limit which appears to be dependent upon maintaining a state of equilibrium so far as concerns the strength of the solution in question within and without the plant.[1] Substances which are necessary to the existence of the plant are withdrawn from the point of ingress rapidly and are elaborated to form parts of the essential constituents of which the plant is composed. In view of the fact that certain bases and acids are not found in plants in the proportion in which they are met by the roots, it is evident that this decomposition must be effected either outside of the plant or else within the same. If the former view were held it would not necessitate the acceptance of a power on the part of the plant to excrete by its roots substances which it does not require; while with the latter, such would be the case. That both views are held may be shown by citing two well-known authorities. Vines[2] calls particular attention to the fact that plants have the power of appropriating an acid and leaving the base, or of appropriating a base and of leaving behind the acid with which it was combined. He claims that this decomposition is effected outside of the plant by the acid sap of the roots. Storer[3] assumes that it is probable that certain substances may enter the plant, become decomposed therein, and excessive accumulations of such as are not utilized may pass out again in the same manner in which they entered. The process by which these materials enter the plant and by which Storer claims they are excreted is that of osmose, i. e., the diffusion of fluids through porous partitions or membranes. Goodale[4] in speaking of constituents being taken up by the plant in larger proportions than are demanded, says: "The excess may (1) remain in solution in the sap of the plant, (2) may escape to a slight extent through superficial parts, (3) may form insoluble incrustations or concretions upon or in the plant;" but he does not state that plants excrete through their roots mineral substances which they do not need, as claimed by Storer. Heiden[1] states that the plant must take up to some extent that which it finds offered to it in solution. To show that the various salts are taken up nearly in proportion to the requirements of the plants for the same and not in that in which they exist in the medium in which they vegetate, he cites Sassure and Gorup-Besanez. So far as concerns the particular point which we desire to make in this connection, it is immaterial whether the view of Storer or that of Vines is correct, and it is our purpose merely to call attention to the fact that plants do exert indirectly as above stated what might be called a selective power[2] so far as concerns the proportion of soil ingredients removed; so that if certain bases combined with nitric acid are offered to the plant, the nitric acid may be appropriated to a greater extent than the bases leaving a basic residue; while on the other hand, if sulphate or muriate of potash were employed the base would be utilized by the plant the more rapidly, by which an acid residue would result. It seems reasonable to assume that this principle, which has been recognized as true in water culture, may also apply under conditions which exist in the soil. So far as concerns the combinations of bases with phosphoric acid, it will be evident from the composition of agricultural plants that the phosphoric acid is largely utilized in the formation of the plant. The same is true of the nitric acid of the various nitrates, which plays such an important part in the formation of albuminoids (the muscle-producing constituent of plants) and amides; sulphuric acid is likewise used to some extent, sulphur being an essential constituent of the albuminoids. In relation to chlorine, as, for example, in muriate of potash, it contributes but slightly to the plant in comparison with the acids above mentioned. In view of these considerations the basic or acid tendency of the various fertilizing ingredients seems to be assured. Adolf Mayer,[1] in recognition of the principles above enumerated, has classified certain manurial substances, part of which are given below in accordance with his grouping:

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[1] Certain small quantities of mineral ingredients are said to be excreted as an effervescence by means of the leaves, and also to be deposited in a crystalline form within the plant in a manner non-essential to its existence.

[2] Physiology of Plants. 1886, p. 56.

[3] Agriculture, Vol. I. p. 185.

[4] Physiological Botany, 1885, p. 252.

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[1] Düngerlehre, Bd. I, 1879, S. 290.

[2] Gorup-Besanez states that according to the nature of the plant a certain choice takes place, and this is not only true of land plants but of water plants also which can draw their inorganic food only from solutions. (Lehrbuch der Phys. Chemie 4 ter, Aufl. S. 24.)

1. PHYSIOLOGICALLY NEUTRAL.

    Calcium sulphate (gypsum),
    Magnesium sulphate,
    Sodium chlorid (common salt),
    Superphosphate,
    Potassium nitrate. (This approaches closely group 3).

2. PHYSIOLOGICALLY SOUR.

    Potassium chlorid (muriate of potash),
    Ammonium sulphate,
    Potassium sulphate,
    German potash salts in general.

3. PHYSIOLOGICALLY BASIC.

    Calcium carbonate,
    Wood ashes,
    Caustic lime,
    Potassium carbonate,
    Undissolved calcium phosphate,
    Sodium nitrate (nitrate of soda),
    Bone meal.

Aside from the substances which have been particularly discussed above, the plant of course finds at disposal bicarbonates which have been produced by the solvent action of the carbonated water of the soil; the acid being produced by the continual decomposition of organic matter. Furthermore, basic constituents of the soil are dissolved by the root secretions and thus enter the plant. It is claimed that bases may be withdrawn by the plant from humates and silicates.[1] E. W. Hilgard,[2] in commenting upon our views in regard to the tendency to acidity in soils, adds "nor can it well be questioned that the constant withdrawal of basic ash ingredients which exist as neutral salts in the soil must create a tendency to acidity." Where nature is allowed to take her course and plants are returned to the soil, the basic ash ingredients in excess[3] of the mineral acids present would be eventually changed into carbonates, nitrates, humates, etc., in the natural processes of decomposition and be again largely taken up by plants. On the other hand, where artificial manuring is not resorted to and the plants are annually removed from the soil, a depletion of the bases therein would naturally result.

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[1] Landwirt. Versuchs-Stationen, 26, 1881, S. 94-95.

The effect upon the soil of the application of certain fertilizing substances due solely to chemical changes now remains to be considered. In the use of highly nitrogenous organic compounds, as for example dried blood, only a minimum amount of bases is present in the material applied. When such material is applied to the soil it undergoes first what is known as an ammoniacal fermentation, the result of which is the production of ammonia, a base, and this undergoes, under favorable circumstances, in consequence of the action of the nitrifying organisms of the soil, a rapid change to nitric acid. During such portions of the year as soils are not occupied by growing plants the nitric acid produced by such means is leached out of the soil in combination with the bases with which it has united, notably with lime and magnesia. Where sulphate of ammonia is applied, the ammonia goes through changes and exerts an effect analogous to that described above, while the sulphuric acid seizes upon the basic constituents of the soil. Thus the tendency of sulphate of ammonia to reduce the basic properties of soils must necessarily be great. In case of the potash salts, they are said to undergo double decomposition within the soil. In soils which contain carbonate of lime, the interchange of bases and acids is said to be hastened by the action of the carbonic acid of the soil water,[1] so that if the sulphates and chlorides of sodium and potassium are applied to such land, the sulphuric and hydrochloric acids combine with calcium, and the carbonic acid with the sodium and potassium; and, owing to the fact that one part of gypsum is soluble in four hundred parts of cold water, and by virtue of the extreme solubility of calcium chloride, it will be seen that the tendency of such applications, particularly those of muriate of potash and common salt, would be to hasten rapidly the exhaustion of the carbonate of lime from the surface soil by the natural operations of leaching.[2] The immediate effect of such double decompositions, as those mentioned above is said to be an increase of alkalinity owing to the fact that the carbonates of soda and potash produced are more basic than carbonate of lime. It should be borne in mind, however, so far as concerns the potash salts which are immediately under consideration that they are rapidly utilized by plants, so that the final result of such an application would not be an increase of the basic properties of the soil, but on the contrary a more rapid depletion of any carbonate of lime which it may originally have contained. Where applications of fish and tankage are made it would not be at all improbable that the nitrogenous portion of the same would as a result of its eventual change to nitric acid, act like blood in hastening the depletion of basic carbonates within the soil. This may explain the observations of practical farmers which have frequently come to our notice to the effect that large applications of fish upon soils presumably poor in lime seem, though exhibiting a beneficial influence the first year, to have resulted in final injury and to have favored in a marked degree the growth of sorrel. This seems to be a reasonable explanation of these practical observations which so far as we know have not been heretofore satisfactorily explained.

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[1] Landw. Versuchs-Stationen, 26, 1881, S. 90.

[2] Private communication, referred to by permission.

[3] Plants usually contain bases more than sufficient to combine with the mineral acids present.

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[1] Adolf Mayer, Landw. Versuchs-Stationen, 1881, S. 91.

[2] Storer Agriculture, 1889, Vol. II, p. 125.

In addition to what has preceded, mention should be made of the occasional presence in soils of protosulphate of iron, a product of the oxidation of pyrite or sulphide of iron and which gives a decidedly acid reaction. Some soils have likewise been found to contain formic and acetic[1] acids.

In *wet* locations where large quantities of organic matter undergo decay, enormous amounts of humus accumulate as a result of the decomposition. Such humus is said to be usually, though not always, in an acid state. The acidity is naturally dependent upon a lack of bases with which the organic acids produced, can combine. In the writings of American agricultural chemists, little reference is made to the development of an injurious degree of acidity due to such causes, in upland or well-drained soils. When we consider, however, the nature of very sandy soils, particularly such as are derived from granite (and from certain mica schists) containing orthoclase instead of oligoclase and mica instead of hornblende, it will be seen that the quantity of bases gradually liberated and at disposal for the neutralization of the organic acids produced by the decomposition of plants, is small. Taking this view of the matter the occurrence of acidity under the conditions above described seems reasonable.

Mention has been made elsewhere of statements[2] to the effect that plants by virtue of the acid secretions of their roots are able to withdraw bases from zeolitic compounds, though no statement has come to our notice in relation to whether such a withdrawal would so change these compounds as to cause them to exert an acid reaction upon blue litmus paper.

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[1] Mulder Chemie der Ackerkrume, Berlin, 1863, Bd. I, S. 360. According to G. Paturel, acetic acid has also been recognized by Dehérain in a soil from Brittany. See Annales Agronomique, 20, 1894, p. 382.

[2] Adolf Mayer; Land. Versuchs-Stationen, 26, 1881, p. 90.

SOILS CONTAINING ANY CONSIDERABLE AMOUNT OF CARBONATE OF LIME ARE SAID TO BE ALKALINE OR NEUTRAL AND NOT ACID, OR IN OTHER WORDS NOT TO REDDEN LITMUS PAPER.

Müntz and Girard[1] in discussing soils of granitic or of sandstone origin, cite as examples of such, certain soils of Brittany, also of Central France, and the region about and to the southwest of the Vosges mountains, and state in relation to them that they are practically devoid of carbonate of lime and tend to accumulate organic matter produced by vegetation which in consequence of a lack of lime is transformed into brown products giving an acid reaction, the nitrogen of which is not apt to nitrify. They state elsewhere[2] that organic matter when not neutralized by a base plays the role of a veritable acid, which is capable of decomposing carbonate of lime and of eliminating carbonic acid, forming a neutral or rather alkaline product nearly insoluble in water, which is known as humate of lime. Detmer[3] states that the amount of carbonate of lime in the soil stands in close relation to the reaction of the same, a condition which is easily understood when one remembers that carbonate of lime is able to destroy the acid reaction of soils and Stöckhardt[4] found in examining certain marsh soils that those which contained only a small per cent. of carbonate of lime gave an acid reaction, while those which contained a large percentage were alkaline. M. Paul de Mondesir[5] calls attention to the fact that a soil may be acid and still contain small quantities of carbonate of lime, but that in such cases the lime is present in grains of considerable size, probably enclosed by particles of clay, under which circumstances it would present only a small surface to the action of soil water, on account of which its neutralizing action would be reduced to a minimum.

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[1] Les Engrais, Tome 3, pp. 190–191.

[2] Ibid, p. 175.

[3] Landwirtschaftliche Bodenkunde, 1876. p. 451.

[4] Hoffmann's Jahresb. d. Agricultur, Chemie, 1866, S. 10.

[5] Annales de la Science Agron. 1887, Tome 2, pp. 273–274.

THE INFLUENCE OF LIMING UPON THE VEGETATION OF SOILS WHICH CONTAIN NATURALLY BUT LITTLE CARBONATE OF LIME.

P. Pichard,[1] in speaking of the silicious soils of Prittany, which are poor in assimilable potash, devoid of lime, but rich in organic matter, says "the application of lime raised the yield of fodder beets from 6,315 kilograms to 21,627 and 38,700 kilograms per hectare, or in other words the yield was quadrupled and sextupled. An addition of plaster still further increased the yield." Müntz and Girard,[2] in discussing certain granitic and sandstone soils of France which are devoid of lime and in consequence noted for their sterility, speak of the disappearance of undesirable species, and the appearance of good grasses and leguminous plants in their place as the result of liming. They state likewise that astonishing results were produced by lime upon the growth of clover, sainfoin and alfalfa, the first and last of which have already been tested upon our Rhode Island soils and found to be wonderfully benefited by lime. Dehérain[3] calls attention to observations by Philippar to the effect that upon the granitic soils of Brittany the culture of the scarlet and red clover was impossible until lime was applied; the soil being originally devoid of this constituent. He also states that Limoüsin, a section in the central portion of France, had remained in a miserable condition for centuries, and that it was not transformed to the state of relative prosperity which it at present enjoys until the construction of a railroad rendered possible the introduction of lime at a low price. He states particularly in this connection that the culture of clover, which was unknown up to that time in that granitic country, became possible after the introduction of carbonate of lime. Storer[4] states that "it is said to be commonly remarked in England that the clay and loamy soils of that country are fertile only when they contain an appreciable quantity of lime." He further adds "that limestone regions are fertile regions almost everywhere." Recent experiments with lime at the Maryland Agricultural Experiment Station[1] have shown a similar beneficial effect upon grasses and clover to that observed at this Station. It appears unnecessary to cite further examples for the purpose of illustrating the beneficial action of lime upon such soils, particularly in connection with the growth of certain crops. Almost innumerable examples might be brought forward from the mass of testimony in this line, particularly in Europe and some sections of the United States.

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[1] Comptes Rendus, Tome 119, No. 10, p. 478.

[2] Les Engrais, Tome 3, pp. 190, 249-250.

[3] Traitè de Chimie Agricole, pp. 580-581.

[4] Agriculture, Vol. II, p. 155.

OBSERVATIONS INDICATING A DEFICIENCY OF CARBONATE OF LIME AND THE PROBABLE ACIDITY OF CERTAIN RHODE ISLAND SOILS.

The observation which led to the extended investigations with lime which have been conducted at this Station, was made by one of us in 1890 in connection with comparative trials of nitrogen in the form of dried blood, sulphate of ammonia and nitrate of soda. In that year like amounts of nitrogen in the above-mentioned forms were employed in connection with dissolved boneblack and muriate of potash. A one-third, two-thirds and full ration of nitrogen were employed in the case of each of the above forms of nitrogen. With an increased application of nitrogen in the form of nitrate of soda, the crop of Indian corn was augmented; where dried blood was used the results were not so satisfactory as expected; and where sulphate of ammonia was applied in increasing quantities the yield decreased rapidly and fell far below that of adjoining plots to which no nitrogen had been applied. In seeking a cause for this remarkable ill effect of sulphate of ammonia two possible reasons suggested themselves. Prior to that time the conditions necessary for nitrification had been studied by Schlössing, Müntz and others, and the only conditions which it seemed probable might be at fault, were the alkalinity or acidity of the soil and the presence or absence of the nitrifying organisms. In view, however, of the fact that protosulphate of iron was not found, and that the possible destruction of the nitric ferment thereby was therefore out of the question, and furthermore, the discovery of the probable universal presence of the nitric ferment by Müntz[1] narrowed the question down to a consideration of the reaction of the soil. The watery extract was found to give with carefully prepared neutral litmus solution, a slight acid reaction, and upon moistening the soil and pressing it about a strip of blue litmus paper it was found to impart a decided red color to the same which persisted upon drying. As a result of this examination it was concluded that the ill effect of the sulphate of ammonia was probably attributable to a lack of basic constituents in the soil, on which account it may have remained in an untransformed state. Possibly some of the ammonia may have united with the organic acids of the soil, as claimed by Mulder[2] to be possible, in the case of protosulphate of iron, and that the injurious action may have been due to sulphuric acid thus liberated, which, as has been shown by Farsky,[3] is injurious to vegetation. As a result of the above diagnosis, it was decided to make an application of air-slacked lime with the hope thereby of overcoming the ill effect of the sulphate of ammonia. The results thus secured were highly satisfactory, as may be seen by reference to the extended observations[4] that have been made at this Station. The benefit thus derived may be claimed to have been due either to the physical or chemical action of the lime upon the soil, or the combination of both factors. We are well aware that air-slacked lime may improve decidedly the physical character of clayey and sandy lands; and, as has been recently shown by Dehérain,[5] liming may facilitate in a high degree the æration of the soil, which in other of his experiments[1] has been shown to affect decidedly the progress of nitrification. In view, however, of the thorough tillage resorted to in this instance, together with the fact that the soil is a sandy loam and not a compact clay, it would not seem reasonable to attribute the beneficial action of the lime in this case solely to its effect upon the physical conditions of the soil. It therefore appears highly probable that the action must have been attributable to chemical changes such as the double decomposition of the ammonium salt effected by the carbonate of lime, or to the partial neutralization of the soil acidity. At all events had the soil been well supplied with carbonate of lime the necessity for its application either for the accomplishment of the chemical or physical purposes mentioned above, would have been unnecessary, and bearing in mind that soils which contain any considerable amount of carbonate of lime do not give an acid reaction, or in other words, do not redden blue litmus paper, it must be evident that the application of this test is well calculated to indicate one of the first requirements of such soils regardless of whether the effect which the lime produces is a physical or chemical one.

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[1] Bulletin No. 35, p. 198.

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[1] Compt. Rend. 110 (1890) p. 1370, Abs. E. S. R., Vol. III, pp. 114-116.

[2] Chemie der Ackerkrume, Bd. II, p. 87.

[3] Biedermann's Central-Blatt, 1886, p. 453.

[4] Sixth Annual Report R. I. Agrl. Expt. Station, 1893, pp. 206-267.

[5] Annales Agronomique, 22, No. 2, 1896, pp. 40-86.

In trials of nitrogen in the form of dried blood, nitrate of soda and sulphate of ammonia, at Hope Valley, R. I., the sulphate of ammonia gave good results the first year, only fair results the second year; and the third year positive injury resulted from its use. In this case the moistened soil was found to quickly and permanently redden blue litmus paper, and subsequently air-slacked lime was used in connection with it with the most gratifying results. Upon immediately adjoining plots where nitrate of soda was used in quantities furnishing nitrogen at the same rate, an application of air-slacked lime did not visibly affect the yield of Indian corn, but in connection with ammonium sulphate the yield was wonderfully increased. (*See figures 1 and 2*). Indian corn is a plant which appears not to be seriously affected by a de-

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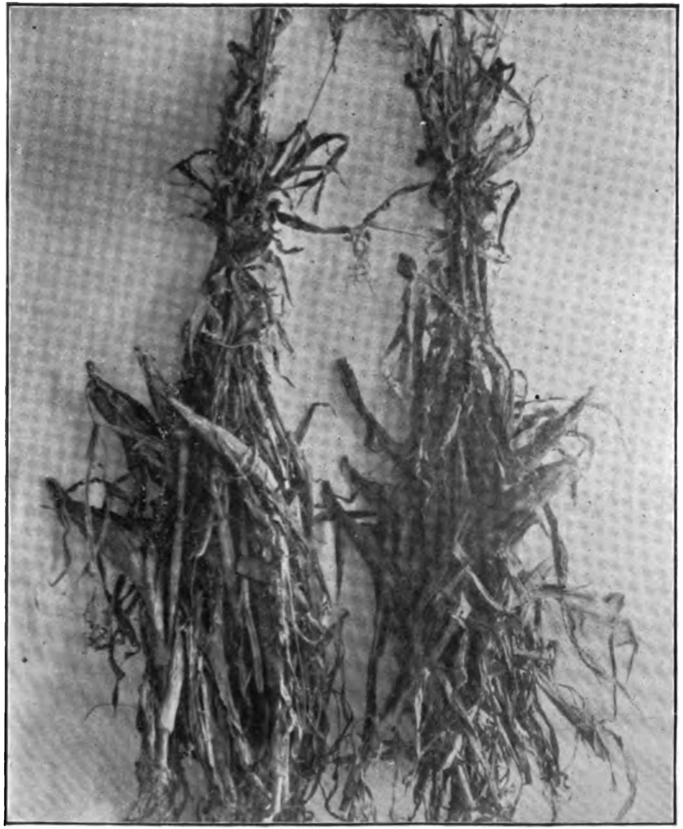
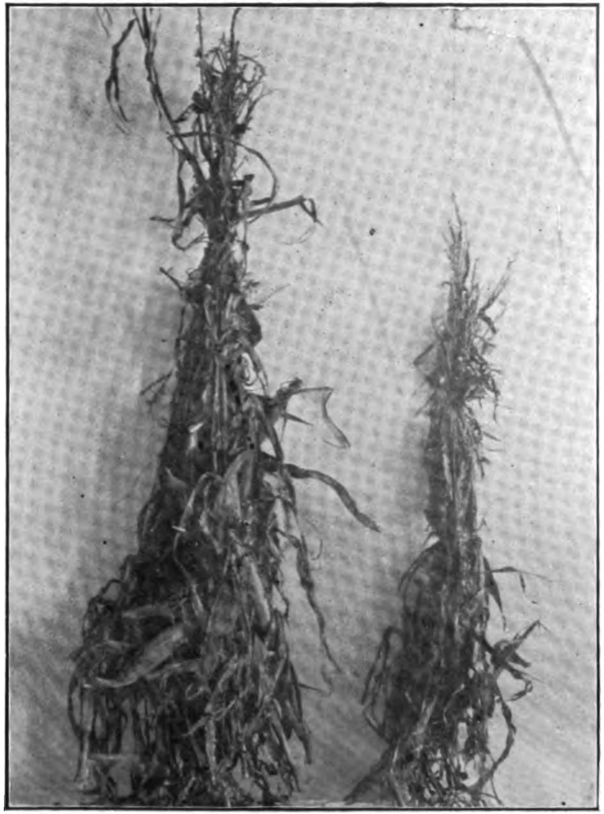
[1] Annales Agronomique, 19, 1893, pp. 401-417.



Limed. FIG. 1. Unlimed.

Muriate of potash, dissolved boneblack and *nitrate of soda*.

INDIAN CORN.



Limed. FIG. 2. Unlimed.

Muriate of potash, dissolved boneblack and *sulphate of ammonia*.

ficiency of carbonate of lime, and the accompanying acidity of soil, which furnishes a satisfactory explanation for the fact that the yield was not materially increased where the lime was used in connection with nitrate of soda. In the case of the sulphate of ammonia, either the absence of carbonate of lime and other basic ingredients or the probable greater acidity of the soil due to the use of this compound, or perhaps both of these factors, contributed to the results noted. It matters not if the ill effect[1] of the sulphate of ammonia be accounted for upon the ground that it had acted as a direct poison or had increased the acidity to an extent injurious to the corn, or had produced by double decomposition within the soil compounds noxious to the corn, for it must be conceded that none of these conditions could have resulted had sufficient lime been present in the soil. This is evident from the fact that air-slacked lime overcame the difficulty whatever it may have been. As was stated in relation to the experiment at Kingston, had a deficiency of carbonate of lime not existed, there is every reason to believe, from the testimony of authorities before cited and in view of our own experiments that the soil would not have permanently reddened blue litmus paper, or in other words, would not have been acid. When we consider that a positive ill effect was produced by the sulphate of ammonia in Kingston the first year, and at Hope Valley not until the third, it will be evident that the Hope Valley soil was less deficient in basic ingredients than that at Kingston, and such being the case it may have been also less acid. In Abbott Run, R. I., a similar though less marked decrease in the yields from the use of sulphate of ammonia as compared with those from nitrate of soda was noticed, and had the experiment been continued a year or two longer it is probable that a similar ill effect would have been eventually noticeable there also. This soil while permanently reddening litmus paper exerted an apparently less intense action than that at Hope Valley or at Kingston. It seems probable that adjacent to some of the limestone deposits of the State, and in case of soils in limited areas which have been derived from hornblendic and other rocks naturally richer in lime and other basic ingredients than our granite and mica schists, that an adequate supply of bases may not only exist at present, but will perhaps be liberated with sufficient rapidity with the lapse of time so that even with the use of artificial fertilizers resort to liming may never become necessary; yet upon the soils of a large portion of the State there is every reason to believe in consideration of the rocks from which the soils are derived, that varying deficiencies of basic ingredients exist, and that while plants like rye, Indian corn, water melon, sheep's fescue, R. I. bent grass, and certain others, may thrive nearly as well or better upon these soils before than after liming, others which require much carbonate of lime or are injured by acidity, such as clover, barley, timothy, lettuce, spinach, beets, etc., may fail or partially fail upon such lands. Upon the Kingston soil, which may be looked upon as a type of those soils extremely deficient in basic ingredients, beets, spinach, lettuce, clover and timothy are almost a total failure unless lime, barnyard manure or other basic ingredients are applied to the soil, while at Hope Valley and Westerly, upon soils which have been tested experimentally, the same plants, though succeeding far better than at Kingston, failed nevertheless to do as well as they should. The degree of failure or success in these cases appeared to be measured by the amount of basic ingredients available or gradually rendered available within the soil, or by the degree of acidity resulting in consequence of a lack of such bases. It should perhaps be stated here that carbonate of lime by virtue of its preventing undue acidity and thus controlling the reaction of the soil, is referred to by many writers as being a "regulator."

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[1] This was evidently not wholly due to the fact that the plant failed owing to insufficient nitrification to get the nitrogen which it needed, for the yield was less in this case than where a like amount of potash and phosphoric acid was applied without any nitrogen, from which a positive ill effect was evident.

In view of the fact that certain agricultural chemists and teachers of agriculture have to our knowledge expressed themselves privately as disbelievers in the idea that upland or naturally well-drained soil can become sufficiently acid to injure plants, (excepting perhaps incidentally where protosulphate of iron may be present), and furthermore, that they do not believe that deficiencies of carbonate of lime are at all frequent in New England soils, it seems desirable to touch in detail upon certain observations made at this Station and elsewhere. We will speak first of observations in connection with the growth of about ninety varieties of plants upon limed and unlimed soil upon the Station farm.

One explanation for the wonderful effect of lime upon our soil, and which would perhaps be accepted by some as a full and satisfactory explanation therefor, would be that it had increased the water capacity of the soil, whereby the failure of certain plants was prevented. We take occasion to state at the outstart that we believe decidedly that the application of lime to this soil may not only tend to keep it in a much better physical condition immediately after heavy rains, but also in a condition more conducive to supplying soil water to the plant as needed; it should be stated, however, that beets and lettuce, and particularly spinach, have been sown upon these unlimed plots in comparatively dry periods as well as in wet ones, and that the majority of the plants soon die regardless of the condition of the surface soil so far as concerns its previous aeration and its moisture content. Spinach has been sown in the spring as well as in the autumn, and during dry and wet periods, and invariably a large proportion of those plants which germinated, died before they had put forth their second leaves. In fact most careful observations during a period of three years show that seeds of all kinds germinate apparently as well in this soil before as after liming. Similar observations have been made in the case of either lettuce or beets during the months of May and June in each of the three years and with results analagous to those secured with spinach. Admitting that the physical soil conditions, particularly in so far as they concern the supply of water at the disposal of the plants, would exert a vast influence upon their growth throughout their entire existence it seems to us inconceivable that the *minute plants above enumerated* should upon the unlimed soil have failed to exist owing either to a superabundance or a deficiency of water, and this is strongly emphasized in view of the fact mentioned above that the same holds true apparently regardless of the rainfall and the amount of moisture in the surface soil, within, of course, reasonable limitations. Seeds of most other plants sown at the same time and upon the same soil not only germinate but the young plants make a good degree of growth, and in some cases grow better before than after liming. In view of the foregoing and in consideration of the fact that the soil is a sandy loam and therefore not sufficiently compact to preclude aeration, or the ready penetration of its mass by the roots of the young plants, the most reasonable explanation to be found seems to be that there is a deficiency of basic ingredients in the soil, to which the formation of substances noxious to the plant may be attributed, or as a result of which the soil may become acid. It is possible that the soil may contain noxious ingredients which are of themselves not acid, or which would not redden litmus paper, yet it appears probable that the noxious ingredients of the soil are acids or acid compounds. The fact that an application of lime counteracts this injurious action is abundant evidence that this ingredient performs an important function in our soil. In consideration of the fact that if carbonate of lime were well disseminated in the soil originally in any considerable quantity the soil would not be acid, or in other words, it would not impart a red color to blue litmus paper, then the imparting of such a color must be looked upon as indicative of a need of lime in that particular form.

In order to ascertain more definitely if possible whether the beneficial action of the lime was due to its having overcome or reduced the acidity of the soil, or to its action in other respects, certain experiments have been conducted at this Station which we will now review as briefly as possible.

The first experiment which we will mention, viz., that of 1894, was one in which pure carbonate of soda and caustic magnesia were compared with air-slacked lime in regard to their relative effect upon the growth of beets. For this purpose galvanized iron ash cans, 26 inches deep and 18 inches in diameter were employed. The bottoms of these cans were inclined towards the center, at which point an opening was left for the purpose of affording drainage. A layer of cobble stones was first placed in the bottom and upon these were filled 144 lbs. of subsoil from the Station plain. Each pot then received 100 lbs. of surface soil from the manured 00 plot of the so-called coöperative acre. Ten pots were employed in this experiment, each of which received 17.38 grams of nitrate of soda and 22.07 grams of dissolved boneblack. All of the pots except two (85 and 86) received muriate of potash at the rate of 7.36 grams, while in the other two pots a like amount of potash in the form of pure carbonate of potash was employed. Two of the pots (93 and 94) received each 91.98 grams of air-slacked lime, i. e., at a rate equivalent to 2½ tons per acre. Two of the pots (91 and 92) received no further addition. Pot 89 received 8.3 grams of carbonate of soda, i. e., at the rate of 450 lbs. per acre, and pot 90, 16.6 grams, i. e., at the rate of 900 lbs. per acre. To pot 87, 3.81 grams of caustic magnesia were added, an amount which, as ascertained by chemical tests, was found capable of neutralizing the same amount of acid as the pure carbonate of soda at the rate of 450 lbs. per acre. In pot 88 twice this amount of caustic magnesia was employed, or sufficient to neutralize the same amount of acid as carbonate of soda, applied at the rate of 900 lbs. per acre. Pots 85 and 86, as stated above, received the same amount of potash as the others, though it was applied as carbonate, which is alkaline in its action, and which when removed from the soil by plants, would not, like the muriate of potash, leave a strong mineral acid as a residue. The amount of carbonate of potash applied being limited to correspond to the amount of potash used in the form of muriate, it was in consequence so small that it could not be expected to lessen to any particular extent the immediate acid properties of the soil. Mangel wurzels were employed in this experiment. Seeds were planted in each pot at four places, and upon the appearance of the young plants all but the most vigorous pair in each lot were removed; and later when these were somewhat more developed they were thinned to four plants per pot, the better of the two individuals being left in each case. So far as concerns cultivation and watering, each of the pots received, so far as was possible, the same treatment. The beet roots, the weights of which are given in the following table, were sliced thinly and air-dried under like conditions in the laboratory for several weeks, or until they were as dry as it seemed possible for them to become under such circumstances.

Table Showing the Comparative Effect upon the Yield of Beets (Mangel Wurzels) of Applications of Carbonate of Soda, Caustic Magnesia and Air-Slacked Lime, 1894.

No. of Pot.	Material Applied* (Weights in grams).	Weight of Air-Dried Beet Roots (in grms.)
	Carbonate of Potash Group.	
85....	5.84 grms. Carbonate..............................	53.6
86....	5.84 " "	67.1
	Muriate of Potash Group. (7.86 grms. Muriate of Potash per pot).	
87....	3.81 grms. Caustic Magnesia........................	89 9
88....	7.62 " " "	130.0
89....	8 3 " Carbonate of Soda	123.4
90....	16.6 " " "	133.5
91....	No special addition................................	91.7
92 ...	" " "	89.7
93....	91.98 grms. Air-slacked Lime......	144.2
94....	91.98 " " "	135 8

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* Each pot received a further application of 17.38 grms. of nitrate of soda and 22.07 grms. of dissolved boneblack.

From the foregoing table it will be seen that the weights of beets from the pots which received their potash in the form of carbonate of potash (85 and 86) are even less than those from the pots which received potash in the form of muriate (91 and 92). Those which received air-slacked lime in addition to the potash, phosphoric acid and nitrogen, (93 and 94) show, as will be seen, large yields, far greater in fact than any one of the four pots mentioned above. The half ration of caustic magnesia (87) produced results slightly better than one of the muriate of potash pots (92) and less than the other (91). However, the pot receiving the full ration of caustic magnesia shows a decided increase, approaching closely one of the limed pots (94). The result from the pot which received a half ration of sodium carbonate (89) is much better than from that which received the half ration of caustic magnesia or than those from any of the pots which received only potash, phosphoric acid and nitrogen. The yield from the pot which received the full ration of sodium carbonate (90) stands between that of the full ration of caustic magnesia and the lesser of the two limed pots.

In 1895 this experiment with beets (mangel wurzels) was continued in the same pots and soils used in 1894. In order that the plants might have an ample supply of phosphoric acid, nitrogen and potash, the quantities of dissolved boneblack, nitrate of soda and muriate and carbonate of potash were increased. The quantities of the two latter ingredients were so adjusted as to furnish potash at the same rate. The pots which had received air-slacked lime at the rate of 2½ tons per acre were given in 1895, 18.4 grams per pot, or the equivalent of ½ ton per acre so that the combined applications of the two years amounted to 3 tons per acre. In order that more space might be allowed for each plant, the number allowed to grow was limited to three in 1895 instead of to four as in 1894. In 1895 the beets were sliced as in 1894, then air-dried and subsequently brought to constant weight at a temperature of 100°C. The results secured are embodied in the following table:

TABLE SHOWING THE COMPARATIVE EFFECT UPON THE YIELD OF BEETS (MANGEL WURZELS) OF APPLICATIONS OF CARBONATE OF SODA, CAUSTIC MAGNESIA AND AIR-SLACKED LIME, 1895.

No. of Pot.	Material Applied* (Weights in grams).	Weight of Air-Dried Beet Roots (in grms.)
	CARBONATE OF POTASH GROUP.	
85....	7.7 grms. Carbonate of Potash......................	44.
86....	7.7 " " "	58.
	MURIATE OF POTASH GROUP. (10. grms. Muriate of Potash per pot).	
87....	3.81 grms. Caustic Magnesia........................	100.1
88....	7.62 " " "	126.3
89....	8.3 " Carbonate of Soda........................	131.5
90....	16.6 " " "	131.3
91....	No special addition	5.2
92....	" " "	91.3
93....	18.4 grms. Air-slacked Lime........................	148.2
94 ...	18.4 " " "	132.0

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* Each pot received a further application of 20 grms. of nitrate of soda and 25 grms. of dissolved boneblack.

By comparing the yields from the pots which received carbonate of potash (95 and 96) with those where the muriate was employed (91 and 92) it will be seen that the larger one in the former case is not equal to the larger in the latter case. It should be noted that the yield from pot 91 is small, which we attribute to the fact that the individual plants chanced to possess a less degree of inherent vitality than those in pot 92, and consequently were not so well able to thrive under unfavorable conditions. The individuality of plants of the same kind in this respect is strongly marked as has also been observed by us in other experiments. From an examination of the results secured in 1894 and 1895, it will be seen that the one-half ration of caustic magnesia proved inferior to the corresponding ration of carbonate of soda in each year, a fact which is readily accounted for, if the benefit derived from their use was in any considerable degree due to their having reduced the acidity of the soil, for a part of the caustic magnesia would tend to change into carbonate in the soil and remain there in a comparatively insoluble condition, in consequence of which it would become less thoroughly disseminated than the carbonate of soda, which is easily soluble. The same would be expected to hold true also in the case of the full rations, and in fact by a comparison of the yields, that from the full ration of caustic magnesia, though good, is not equal to that from the full ration of sodium carbonate in either year. By a comparison of the yields from the full ration of caustic magnesia and of carbonate of soda it will be seen that they approach closely that of one of the limed pots, though they are somewhat inferior to that from the other. It is evident, therefore, that these compounds have exerted an effect nearly equal to that produced by lime. If the beneficial effect of the carbonate of soda and caustic magnesia is attributed solely to their physical influence upon the soil, then it must be conceded that they are nearly equally efficient for this purpose; on the other hand, if it is claimed that the action observed is due to a direct fertilizing effect, then one must assume that each can perform largely the function of the other, and while there are some experimental data justifying this idea in the case of the lime and magnesia there seems to be little or no ground for claiming that their place can be filled by soda. Again, if this is explained upon the ground that these ingredients exerted an indirect fertilizing action by setting free other elements in the soil which the plant required, the question next arises what could these elements have been? If it were claimed that the beneficial action of the lime was due in 1894 to the liberation of potash, phosphoric acid or nitrogen, why should it have had an even more marked effect in 1895 than in 1894, particularly in view of the fact that greater quantities of phosphoric acid, potash and nitrogen were applied in 1895 than in 1894, under which circumstances exactly the opposite effect would have been expected. What has been said of lime in this particular is equally true of the caustic magnesia and carbonate of soda. It does not, therefore, appear probable that the benefit from these compounds was due wholly or even chiefly to either a direct or indirect fertilizing action; we therefore return to a consideration of the possible physical action of these compounds. It must be conceded that the chief physical benefit said to be derived from the use of lime upon soils is the rendering of clays more friable, and of light, sandy soils more compact, by which their physical condition and water capacity are improved. Other points like ease of tillage, etc., resulting therefrom, we will leave temporarily and consider the question of the water at the disposal of the plants. During both years the plants were carefully watched and upon an indication of a lack of water its application was resorted to, on which account it does not seem to us reasonable to attribute more than a limited portion of the observed differences to the effect of these compounds upon the water capacity of the soil. Certain soils are said to absorb and hold certain fertilizers more readily after liming than before. This being particularly true of light, sandy soils in connection with the use of superphosphates. In view, however, of the large applications of dissolved boneblack made in this experiment, it seems wholly unreasonable to explain the observed results upon this basis. It appears, therefore, to be the most reasonable supposition, that the chief benefit observed was due to the neutralizing function of these compounds in the soil, or to their having changed into a non-injurious form certain pre-existing noxious soil ingredients; and once more we must state that had the soil not been deficient in carbonate of lime such noxious constituents or an injurious degree of acidity could not have existed, facts which point most strongly to the value of an acid test in ascertaining one of the first requirements of such soils.

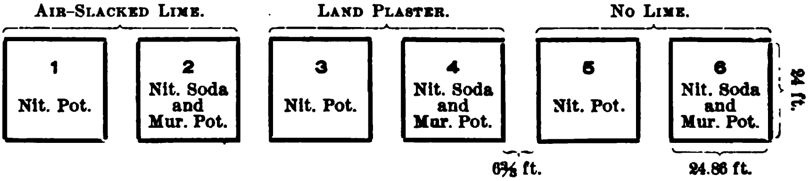
In connection with the foregoing experiments, a trial has been made of the effect of carbonate of soda upon the development of lettuce. The pots employed in this experiment were filled in the same way and with the same kind of soil as those previously described. Four pots were employed, each of which received nitrate of soda, muriate of potash and dissolved boneblack at the same rates as those in connection with the preceding beet experiment. Two of the pots (57 and 58) received no further additions, but to pot 59 a half ration of carbonate of soda corresponding to that used in the foregoing beet experiment, and to pot 90 a full ration of the same was applied. The lettuce was cut and weighed green with the following result:

Pot 57.	without carbonate of soda	0.0	grams.
" 58,	" " " "	0.0	"
" 59,	one-half ration of carbonate of soda	19.0	"
" 60	full ration of carbonate of soda	115.9	"

As will be seen from the foregoing, no yields were obtained from the pots which received no carbonate of soda. In these pots the lettuce seeds germinated apparently as well as in the others, and some of the plants put out their second leaves, which in all cases presented a reddish brown appearance, and with the lapse of time and without material growth all of the plants gradually died. Where the half ration of carbonate of soda had been employed for two successive years the four plants which were finally left, survived, but made only a moderate growth. Where the full ration of carbonate of soda had been used for two successive years, i. e. at the rate of 900 lbs. per acre annually, the growth of the lettuce though not fully ideal was magnificent in comparison with that where the smaller amount was used. (*See Fig. 3.*) *A stone appears in the cut to mark the spot which would have been occupied by the crop from pots 57 and 58 had the young plants not died.*

The line of argument employed in connection with the beet experiment would seem to apply here. It seems most reasonable to attribute the chief action of the carbonate of soda to its having reduced the acidity of the soil or to its having changed to a harmless form noxious ingredients therein.

For the purpose of throwing light upon the action of lime in connection with our soil and in order to employ a fertilizer which would contain no chlorine, to which, injury to certain crops in other experiments upon unlimed soil may have been attributed, the following experiment was planned. Six plots of land, the general arrangement and plan of manuring of which are indicated by the subjoined diagram, were laid out.



Indian corn had been grown without manuring upon the land employed for this experiment in 1893 and 1894, and the growth upon it was as uniform as could well be expected. The quantities of fertilizing ingredients applied to each plot are given in the following table:

KINDS AND QUANTITIES PER ACRE OF FERTILIZERS USED.

	NO LIME.		LAND PLASTER.		AIR-SLACKED LIME.	
	Plot 6.	Plot 5.	Plot 4.	Plot 3.	Plot 2.	Plot 1.
Dissolved Boneblack	800	800	800	800	800	800
Magnesium Sulphate	400	400	400	400	400	400
Muriate of Potash	400	...	400	...	400	...
Nitrate of Soda	386	...	386	...	386	...
Nitrate of Potash	...	474	...	474	...	474
Air-slacked Lime	...	...	...	...	5000	5000
Land Plaster (Gypsum)	...	...	9805.8	9805.8	...	...

It should be stated that the area of each plot was one-seventy-third of an acre. Sugar beets were grown on one-half of each of the plots and red table beets on the other half. Magnesia was applied in the form of sulphate of magnesia (Epsom salts) so that if the plots which received nitrate of soda and muriate of potash gave better results than those which received nitrate of potash, there would be no good ground for attributing the better effect of

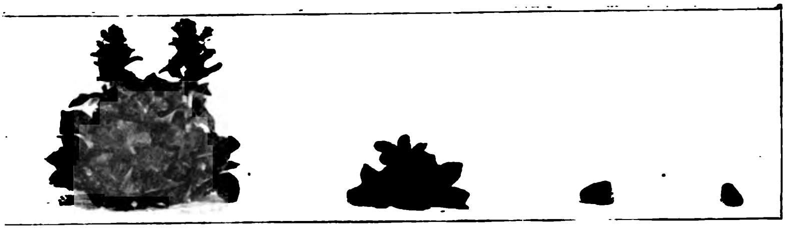


FIG. 3. LETTUCE.

Pot 60. Pot 59. Pot 58. Pot 57.

Pots 57 and 58 had no sodium carbonate, while Pot 59 had a half and Pot 60 a full ration.

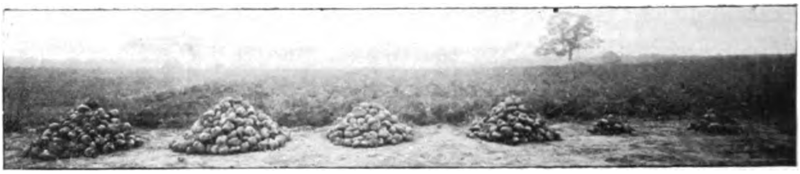


FIG. 4. RED TABLE BEETS.

Plot 6. Plot 5. Plot 4. Plot 3. Plot 2. Plot 1.

Air-slacked Lime. Land Plaster (Gypsum). Unlimed.

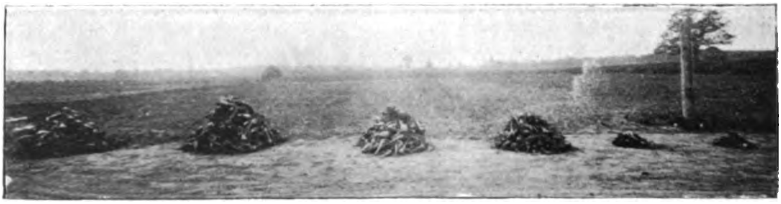


FIG. 5. SUGAR BEETS.

Plot 6. Plot 5 Plot 4. Plot 3. Plot 2. Plot 1.

Air-slacked Lime. Land Plaster (Gypsum). Unlimed.

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the former to the liberation of magnesia within the soil. The quantities of nitrate of soda, muriate of potash and nitrate of potash were so adjusted that the plots which received the two former obtained applications of nitrogen and potash identical with those upon the plots where the latter ingredient was employed. Two plots were left, as will be seen, without an application of lime in any form. Another pair of plots received land plaster (gypsum) and another pair air-slacked lime. The quantities of these two ingredients were such that the actual lime (CaO) employed in each case was identical; so that if a difference was noticed between the results secured with the gypsum and air-slacked lime it would be attributed solely to the difference in the chemical combination in which the lime was applied. The beets harvested from these plots were photographed and are reproduced in the accompanying illustrations. (*See Figs. 4 and 5*).

TABLE SHOWING RESULTS WITH BEETS BY THE USE OF LAND PLASTER (GYPSUM) AND AIR-SLACKED LIME.

	NO LIME.		LAND PLASTER.		LIME.		Per cent. of Gain of the Lime over the Land Plaster Plots.	
	Plot 6.	Plot 5.	Plot 4.	Plot 3.	Plot 2.	Plot 1.		
	Nitrate of Soda and Muriate of Potash.	Nitrate of Potash.	Nitrate of Soda and Muriate of Potash.	Nitrate of Potash.	Nitrate of Soda and Muriate of Potash.	Nitrate of Potash.	Nitrate of Soda and Muriate of Potash.	Nitrate of Potash.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Sugar Beet, roots....	4.50	6.25	66.50	95.00	204.50	174.00	207.52	83.15
Sugar Beet, tops....	5.25	8.00	75.00	85.50	168.50	125.00	124.66	46.19
Table Beet, roots....	14.00	9.50	114.00	129.00	223.50	202.50	96.05	56.98
Table Beet, tops.....	11.00	10.00	52.50	38.50	68.50	73.50	30.47	90.99

As will be seen from the preceding table and from the accompanying illustrations, the beets were practically a failure upon the unlimed plots, and in fact, notwithstanding that the seed appeared to germinate as well upon these plots as upon the others, most of the plants died when small, and those which succeeded in maintaining themselves throughout the season failed to make a satisfactory growth. Comparing the yields upon the plots which received land plaster with those where no lime was used, it will be seen that those where plaster was used were wonderfully increased, and it is of particular interest to note that the gain by the use of plaster was greater upon the nitrate of potash plot than upon the one which received nitrate of soda and muriate of potash. Several explanations for this may be possible yet the one which seems highly plausible is that the chlorine in the plots where the muriate of potash was used may have been left behind as a residual product, as a result of the removal of the potash by the plant, and not finding an adequate supply of basic ingredients in the soil it may in temporary combination as hydrochloric acid have exerted an injurious effect less marked, though similar to that observed in water cultures. Even if it is assumed that sufficient soda was left as a result of the decomposition of nitrate of soda by the plant to combine with the hydrochloric acid liberated from the muriate of potash, the common salt so formed may itself have exerted an injurious action. The results observed, however, are perhaps more likely attributable to the former than to the latter action.

Upon a comparison of the yields where air-slacked lime was used with those obtained from land plaster, it will be seen that the air-slacked lime gave a wonderful increase. Furthermore, it is highly interesting to note that unlike the results with land plaster the greater increase in yield was upon the plot which received nitrate of soda and muriate of potash, which finds its probable explanation upon the supposition that where sufficient air-slacked lime was present in the soil to overcome the acid tendency of the muriate of potash the plant was probably in condition to derive some benefit from the presence of the sodium or chlorine, or perhaps from both. It must be borne in mind at this point when one considers the greater yield upon plot 2 as compared with plot 4, that owing to the use of the air-slacked lime the soil conditions were rendered so much more favorable that the plant was in better condition to make use of the plant food at disposal than where the land plaster was used. For this reason the chlorine possibly in some slight degree, and more particularly the sodium, may have had a greater opportunity to come into play in a fertilizing capacity then in connection with the land plaster. As is well known, the experiments by P. Wagner and Dorsch, Atterberg and Pagnoul, indicate that where there is a deficiency of potash, sodium is more likely to be beneficial then where there is not, and it might be argued that owing to the greater growth upon plot 2 such a condition was created upon that plot but not upon plot 4, where the demand for potash was less. Some of these facts mentioned above bear only indirectly upon the particular point to be observed in connection with this experiment, but are of too much interest to be passed over. In comparing the results with air-slacked lime and land plaster in a general way it will be seen that the former was, as above stated, vastly superior to the latter in its action, a point which will next be considered. In order to make the lime (CaO) equal in both cases, a very large application of land plaster was necessitated, and it might be objected that owing to its considerable solubility in water it had exerted an injurious action. When we compare the yields with those obtained where no lime was employed it will be seen that the plaster was on the contrary highly beneficial; it is possible, however, that had less plaster been used equally good if not better results would have been obtained, but had such been the case it might have been objected that the greater yields from the air-slacked lime were due to the fact that a greater amount of actual lime was at the disposal of the plant in that case than in the other, a condition which it seemed imperative to avoid. It may be argued that the air-slacked lime had favored nitrification to a greater extent than the land plaster, but from nitrification experiments made by several prominent investigators it appears that land plaster is highly favorable to nitrification under otherwise satisfactory conditions, so that if one claims that the lime acted better than the plaster owing to its having facilitated in a greater degree the nitrification of the humous nitrogen it is practically an admission that the soil was deficient in basic ingredients. If such were the case then the acidity of the soil becomes probable and the value of a test for acidity is again made obvious. It may perhaps be stated here that a large application of nitrogen was made with the hope that a sufficient supply in an assimilable form would be at the disposal of the plant so that the factor of the influence of those compounds of lime upon the nitrification of the soil nitrogen would if it entered into consideration at all do so to a slight extent only. From a careful consideration of this experiment the most probable explanation of these results seems to be that the soil was in a sufficiently acid condition to affect decidedly the growth of the beets, for had it been solely a question of a lack in the soil of sufficient assimilable lime it would seem reasonable that the land plaster should have exerted an equally beneficial effect. It will be seen again from this experiment that the particular adaptability of a given soil for certain crops is not, other things being equal, measured by the percentage of lime regardless of its chemical combination; and consequently a determination of the lime in the soil, which may be removed by extraction with hydrochloric and certain other acids, may fail utterly to tell whether the land is or is not in need of an application of air-slacked lime or other forms of lime having the same effect. In view of the fact that soils which are deficient in carbonate of lime and other compounds capable of exercising a basic function, exert an acid reaction upon blue litmus paper, the value of the test in a practical way must be obvious. One point has not yet been considered in connection with the foregoing experiment, namely: that of the relative physical effect of the air-slacked lime and the land plaster. If one were to attribute the results obtained solely to the physical action of these compounds then by a comparison of the unlimed plots with those which received land plaster it would have to be admitted that the plaster had exerted a favorable physical action, and again it would involve also the admission that the physical action of the air-slacked lime must have been more favorable than that of the land plaster. Admitting such to have been the case it must be obvious that such a favorable action would not have been produced by the air-slacked lime had carbonate of lime in sufficient quantity been present in the soil, and furthermore had such been the case an acid reaction of the soil would have been practically out of the question. So that if one were to accept the explanation of these results solely upon the basis of a physical action he would be inevitably forced to the admission that the application of the litmus paper test would have been a suitable means of determining this requirement of the soil.

Certain other observations in connection with the use of land plaster have also been made at this Station which bear directly upon this question. In 1893 pot experiments were conducted with Indian corn.[1] In this experiment the total yield of corn from the use of potash and phosphoric acid was 66.8 grms.; where sulphate of ammonia was used in addition, the yield was reduced to 12.6 grms., but where nitrate of soda was used in an amount furnishing nitrogen at the same rate, the yield was 122.6 grms.; where air-slacked lime was used in connection with the phosphoric acid, potash and sulphate of ammonia, the yield where the lime was applied at the rate of one ton per acre was 187.7 grms., and where four tons per acre were employed it amounted to 192.3 grms., but where sulphate of lime, *i.e.* gypsum or land plaster, was used in an amount furnishing lime (CaO) at the same rate as the air-slacked lime at the rate of four tons per acre, the yield was 33.4 grms. In 1894 the same manuring was employed in these pots as in 1893, except that no further application of either lime or land plaster was made. In that year oats were grown instead of Indian corn, and as in 1893, the yield where sulphate of ammonia was used in connection with potash and phosphoric acid, was less than where the two latter ingredients were used alone, while nitrate of soda exerted an influence similar to that seen in 1893. The average yield in 1894 from the pots which received an addition of sulphate of ammonia without lime was 11.9 grams; where lime at the rate of one ton per acre was applied in 1893, the yield with sulphate of ammonia was 65.4 grams, and where four tons of lime were applied per acre in 1893, 76.1 grams; where the plaster was used in 1893, the yield was but 27.5 grams. In 1895 the observations were continued in the same pots under the same conditions without further applications of either land plaster or air-slacked lime. The yields of rye were as follows: where no lime was used the yield with the addition of sulphate of ammonia averaged .9 of a gram; where lime had been previously used at the rate of one ton per acre the yield was 1.5 grams; where four tons of lime were used per acre it was 104.3 grams and where the land plaster was used it was but 1.2 grams. From these results it is plainly to be seen that a positive injury resulted from the use of sulphate of ammonia, for the yield from a given amount of potash and phosphoric acid was far greater without the sulphate of ammonia than with it. In the former case the plants were almost wholly destroyed. The results from the use of nitrate of soda were on the contrary good, and remained so during the two succeeding years. In 1893 and 1894 the results from the use of lime at the rate of one ton per acre in connection with the sulphate of ammonia were good, but not fully equal to those where four tons were used. In 1895 it will be seen that the one-ton application had entirely lost its efficiency, while the results from the pots which received lime at the rate of four tons per acre were still excellent. Where land plaster was employed, notwithstanding that it was at a rate equivalent to four tons of air-slacked lime per acre, it tended to alleviate the ill-effect of the sulphate of ammonia only in a slight degree, the results still falling far behind those secured where potash and phosphoric acid were used without sulphate of ammonia. It should be stated also that during each of the three years the yields where sulphate of ammonia and lime at the larger rate were used in connection with the potash and phosphoric acid, were much greater than where the same amount of lime, potash and phosphoric acid without nitrogen were employed, showing in a striking manner that the nitrogen of the sulphate of ammonia had by the aid of the lime become available to the plants. That the one-ton application should have lost its efficacy by the end of the second year is readily explained upon the ground that it had become neutralized by the acid residues from the fertilizers and by the acid compounds of the soil. Considering the failure of the land plaster, (in which combination it must be remembered that the lime was already neutralized by sulphuric acid) and in view of the fact that the one-ton application of lime lost its efficacy, while that of the four-ton application still continued, the strongest evidence seems to be afforded that the beneficial action of the lime was due not to its virtue as an element regardless of its chemical combination but to its particular action when present as carbonate of lime, so that again, had the soil been sufficiently supplied with this ingredient, no great degree of acidity could have been possible and the value of the litmus paper test is thus indirectly made evident. From a consideration of the above data, it seems to be evident that the recognition of a considerable degree of acidity as indicated by the rapid reddening of blue litmus paper must be important in connection with soils even other than such as contain protosulphate of iron. If such is the case it must furthermore be evident that a practical means of measuring the relative acidity of such soils would place in the hands of the chemist a means of great value in determining one of their chief requirements.

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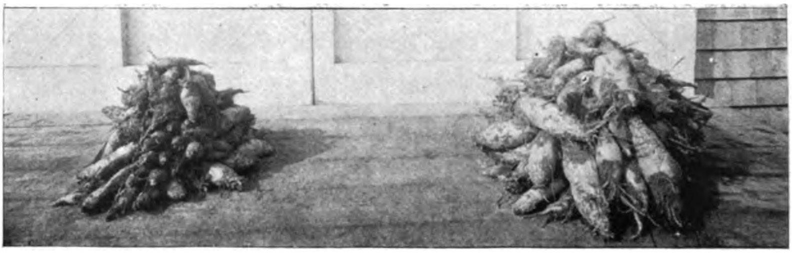
[1] For full description of all the details of this experiment see Sixth An. Rep. of the R. I. Agrl. Expt. Sta., pp. 252-260.

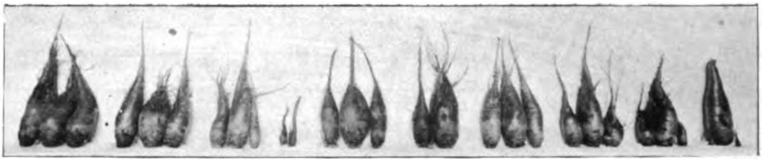
OF THE PROBABILITY OF AN EXTENDED LACK OF CARBONATE OF LIME AND THE PRESENCE OF A CONSIDERABLE DEGREE OF ACIDITY IN UPLAND AND NATURALLY WELL-DRAINED SOILS.

In addition to the observations already referred to which have been made at this Station and at Hope Valley and Abbott Run, R.I., all of which indicate an acid condition of the soil and a deficiency of carbonate of lime, certain others have been made which go to show that such a condition exists to a greater extent than is generally supposed. Upon the occasion of a call at this Station, Mr. F. P. Babcock, of Westerly, R. I., in discussing some of his market gardening experiences mentioned the fact that upon certain portions of his farm he had never been able to secure satisfactory crops of spinach, lettuce or beets, and the idea suggested itself to us that his soil might, like our own, be in an acid condition and therefore deficient in carbonate of lime, to which the results reported might have been attributable. Accordingly in the spring of 1895 arrangements were perfected for the purpose of making an experiment upon a small scale with the hope of ascertaining if this supposition was correct. Two small plots were laid out, upon each of which like amounts of potash, phosphoric acid and nitrogen were applied in forms and at rates as follows: muriate of potash, 400 lbs.; dissolved boneblack, 1000 lbs.; and nitrate of soda, 400 lbs. per acre. One of the plots received in addition air-slacked lime at the rate of 2½ tons per acre. The lime was spread upon the surface of the plot after plowing and well mixed with the surface soil. Nitrogen in the form of nitrate of soda was employed in order that a liberal amount of directly assimilable nitrogen might be present and so that if particular benefit were derived from liming it would be attributable in as slight a degree as possible to its action in effecting the nitrification of the humous nitrogen. Indian corn was planted across one half of each of the plots and mangel wurzels across the other half. In experiments at this Station no particular benefit to Indian corn has been noticeable from liming in cases where nitrogen in the form of nitrate of soda was applied and such proved to be the case in this instance also. The Indian corn upon the limed and unlimed portions exhibited no visible difference, and for this reason no attempt was made to weigh the crop upon the respective plots. The experiment was visited by one of us a few days after the beets came up for the particular purpose of noticing if the seeds had germinated evenly upon both plots, which seemed to be the case. In fact at that time there was hardly a perceptible difference between the plots. About the end of July another visit was made and it was



Unlimed. FIG. 6. MANGEL-WURZELS. Limed.

Both plots manured alike with muriate of potash, dissolved boneblack and nitrate of soda.



MANGEL-WURZELS.

Pots 94. 93. 92. 91. 90. 89. 88. 87. 86. 85.

See pot experiment with beets (1895), page 264.

Pots 85 and 86. Potash in form of carbonate of potash.

Pots 91 and 92. Potash in form of muriate of potash.

The pots below received the following in addition to what was applied to 91 and 92—

Pot 87. Caustic magnesia, 3.81 grms.

Pot 88. Caustic magnesia, 7.62 grms.

Pot 89. Carbonate of soda, 8.3 grms.

Pot 90. Carbonate of soda, 16.6 grms.

Pots 93 and 94. Air-slacked lime at the rate of 2½ tons per acre in 1894 and ½ ton per acre in 1895.

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evident at once that the beets upon the limed plots were far in advance of the others; in fact upon the unlimed plots many of the plants had apparently died since the first visit and many others had a sickly appearance; there were, however, some apparently vigorous plants among them. The chief difference between the two plots consisted in the relative size and color of the plants. At the time of harvesting, a most marked difference was visible. The beets were harvested and weighed with the assistance of Mr. Babcock, to whom we are indebted for the care of the experiment throughout. The weight of roots (*See Fig. 6*), from the unlimed plot was 63 lbs. and that from the limed one, 155 lbs. The weights of the tops were not taken. Owing to the quantities of potash, phosphoric acid and nitrogen applied, it seemed most probable that the action of the lime in this case was attributable to its having served as a direct fertilizer, to its having improved the physical condition of the soil, or to its having lessened the acidity of the soil and at the same time changed undesirable compounds therein into useful or harmless ones. At all events had sufficient lime been present originally as carbonate, no such results could have been expected and the soil would probably not have been of such an acid character. Certainly the results with the lime in this case agreed fully with what would have been expected from the litmus paper test.

Mr. H. E. Taber, of West Kingston, made a trial of air-slacked lime in 1895, upon oats which had been sown with clover, the results of which showed in a marked degree, benefit from liming.

Mr. E. W. Phillips, of Usquepaugh, R. I., reports that he has used lime upon oats and clover with gratifying results. We have not thus far tested the soil of these two farms for acidity, but the soil of a farm immediately adjoining that of Mr. Taber, and samples of others from Usquepaugh and Exeter have shown a very marked reddening of blue litmus paper.

Upon a section of a farm in Bolton, Mass., which consists of sandy loam and upon which sorrel grows readily, and onions and beets have failed to thrive well, and where clover and timothy do not persist, the soil was found, by the blue litmus paper test, to be strongly acid. In 1895 air-slacked lime was used to advantage upon this soil in connection with the growth of table beets, and the owner of the adjoining farm states that he has bought clover hay to feed his stock, having been unable to grow it successfully upon his farm. A similar report has been brought to our notice by Mr. H. W. Collingwood, from North Truro, Mass., and this soil has likewise been tested by us and found to be strongly acid. In experiments conducted at the Massachusetts Agricultural Experiment Station at Amherst, sulphate of ammonia has failed in some instances to work in a satisfactory manner, presumably owing to a deficiency of carbonate of lime. Recently Prof. J. W. Sanborn in commenting upon the experiments at this Station in connection with the use of lime in overcoming the ill effects of sulphate of ammonia, called attention in the *Mirror and Farmer* to the fact that at the New Hampshire Agricultural College, then at Hanover, similar ill effects became visible the second or third year of its use, and in a private communication of a later date he showed that the ill effect increased from year to year and with the amount applied. That these results were due to an exhaustion of the phosphoric acid and potash of the soil is impossible, owing to the fact that both of the ingredients were applied in connection with the sulphate of ammonia. It appears probable, therefore, that the ill effect observed by him could have been overcome by the use of carbonate of lime, or that it was due to a deficiency of basic ingredients in the soil. Owing to the intervening inclemency of the weather the samples of this soil which have been kindly promised us for examination have been unobtainable, and consequently we do not know whether it was acid or not. Mr. G. D. Howe, of North Hadley, Mass., reports that he has observed similar ill effects from the use of sulphate of ammonia in his vicinity. The experience of Ruffin recounted in his book on calcareous manures, and that of the Maryland Agricultural Experiment Station, and of farmers in many other parts of the United States furnish abundant evidence in support of the idea that a deficiency of carbonate of lime exists frequently in this country and that acid upland soil may not be uncommon. In fact the almost universally accepted idea of the acidity of certain of the sandy soils of Germany and France, particularly such as are derived from certain sandstones, mica schists and granites, and which contain a large percentage of silica, together with the beneficial results from liming so frequently recorded in England, all serve to emphasize the importance of ascertaining the presence or absence of carbonate of lime in soils.

SUMMARY.

The removal of plants from the soil and the use of certain fertilizers doubtless exhaust the lime and other basic ingredients of the soil more rapidly than would be the case were nature allowed to take her course.

That an acid condition is liable to result in consequence of the above-mentioned operations, particularly in the case of soils derived from rocks deficient in basic ingredients, we believe to be a reasonable assumption.

While some plants like clover, timothy and beets, appear to be injured by a lack of carbonate of lime or by the resulting acidity of the soil, others appear to thrive best under such conditions.

A strongly marked reddening of blue litmus paper seems to be a simple and effective indication of the condition of a soil in the above-mentioned particulars.

The value of a satisfactory method for determining the relative acidity of soils would seem to be great.

A dangerous degree of acidity or at least a fatal lack of carbonate of lime appears to exist in upland and naturally well-drained soils, and is not confined to muck and peat swamps and very wet lands as most American and many other writers seem to assume, in view of which it appears that the test for acidity should be more generally applied to such soils.

That this condition of upland soils has not been more fully recognized heretofore is not surprising for the reason that the failure or partial failure of certain crops has been attributed to winter-killing, poor germination of seeds, drought, excessive moisture, or attacks by insects or fungi. Upon soils where certain plants are injured only to a limited extent by acidity others would be expected to thrive best of all, in consequence of which it is not surprising that the cause for the partial failure of certain crops upon them has not been suspected.

The inefficiency of land plaster as compared with air-slacked lime in the culture of beets and in overcoming the ill effect of sulphate of ammonia, as well as the highly beneficial results from the use of caustic magnesia and carbonate of soda, all tend to further strengthen the position that the fault of the soil in question is a lack of basic ingredients, to which the presence of noxious compounds which may partly or wholly give rise to the acid reaction, is attributable.

AMMONIUM THIOCYANATE AS AN IMPURITY IN AMMONIUM SULPHATE.

H. J. WHEELER AND B. L. HARTWELL.

C. Schumann,[1] while chemist for the fertilizer manufacturers H. & E. Albert, of Biebrich on the Rhine, examined some "brown sulphate of ammonia" which English manufacturers were offering for sale in Germany. This material was found to contain 30.4 per cent. of nitrogen while sulphate of ammonia contains but about 20.5 per cent. Upon further examination it was found that nearly three-fourths of the material was ammonium thiocyanate. Not being aware of Nobbe's investigations in relation to the effect of this compound upon vegetation and for the purpose of testing its action, some of it was spread upon a meadow at the rate of about 165 pounds per acre. Wherever particles of the material fell, the tips of the grass leaves and soon after the entire aerial portion of the plants turned yellow and died. Later they put out a new growth which was however much weaker than before. The first crop of grass was a total loss. An ammoniated superphosphate which contained 25 per cent. of the same material when used for manuring potatoes exerted likewise a highly injurious influence. P. Wagner[2] describes serious results from the presence of ammonium thiocyanate in a fertilizer used for barley at Hanau, Germany. The direct loss due to the presence of this impurity was estimated at about $400. The seeds did not germinate well and the young plants turned yellow and most of them died, though later after heavy rains a few of them recovered in a measure.

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[1] Landw. Versuchs Stationen, 1872, 15, p. 290.

[2] Jour. f. Landw. 1878, 21, pp. 482–487.

L. Baist in an article in an agricultural paper called attention to the same field but believed the injury to have been due to soluble phosphoric acid. Accordingly Wagner procured soil from the farm where the injury to the barley had resulted and established by careful expriments that the superphosphate had not caused the ill effect, showing conclusively that it was due to the ammonium thiocyanate. Later, Krauch[1] conducted some experiments in pots, each of which contained about eleven pounds of a sandy loam soil. Each pot received 4 grams of an ammoniated superphosphate containing 9.75 per cent. of nitrogen and 10.3 per cent. of soluble phosphoric acid. One pot received no ammonium thiocyanate, while quantities amounting to .05, .10, .25 and .50 of a gramme[2] respectively, were added to each of the others. In this experiment it was found that even the smallest quantity used affected seriously the germination of the seeds and also the subsequent growth of the plants.

In order to test the effect of this compound upon barley which was just ready to bloom, the plants in one pot were watered with a solution of .02 of a gramme of ammonium thiocyanate in about one-fifth of a quart of water and those in another with a solution twice as strong. After the plants which received the stronger solution were watered twice they became sickly and upon a continuance of the treatment they soon died. Where the weaker solution was used, the same sickly appearance of the plants was observed after the third watering. Experiments in the same line in which the plants were grown in solutions instead of in soil resulted similarly. Krauch adds that the poisonous action of ammonium thiocyanate upon barley is hardly less than that of the most powerful poisons upon human life. In addition to the above W. Sigmund[3] calls attention to experiments by Wollny[4] in the same direction and cites his own experience in which a .5 and .3

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[1] Jour. f. Landw. 1882, 30, pp. 271-275.

[2] 28.35 grammes are required to make an ounce.

[3] Die Landw. Versuchs-Stationen 47, 1896, p. 25.

[4] Centralblatt f. Agrikulturchemie Bd. 13, p. 167.

per cent. solution exerted an injurious effect upon peas while a .1 per cent. solution injured them, if at all, but slightly. Most of the ammonium sulphate on the market at the present time is free from this poisonous compound, yet it seems to be occasionally met with. P. L. Jumeau[1] in examining a sample of nitrogenous manure and one of ammonium sulphate "which proved deleterious to the crops for which they were used," found them to contain ammonium thiocyanate, which in the latter of the two materials amounted to 9.39 per cent.

In the spring of 1895 a Rhode Island farmer sent to the Station a sample of brown ammonium sulphate which he had purchased through a regular dealer in commercial fertilizers in another state, and asked if it was all right. It was analyzed and found to contain 20.88 per cent. of nitrogen and was also examined qualitatively for ammonium thiocyanate, the presence of which was readily established by the ordinary well known reactions. Owing to the pressure of work at the time the absolute amount of this impurity was not then determined. In view of its known poisonous character, however, the farmer was told that the safer course would be not to use it though it might contain too little to cause any damage. In order not to take any risk the buyer returned the entire lot to the seller.

Subsequently, when time allowed, the material was examined quantitatively by the first method given by Jumeau[2] and only traces of ammonium thiocyanate were found. In the meantime also pot experiments were undertaken for the purpose of testing the material itself and also with a view to testing more critically the claimed poisonous action of this compound. In experiments conducted at this Station ammonium sulphate which was known to be free from ammonium thiocyanate has exerted a positive poisonous action which was supposedly due to a deficiency of carbonates in the soil which gave rise to a considerable degree of soil acidity. In view of these experiments and similar ill effects from ammonium sulphate noted elsewhere it seemed possible that at least some of the ill effects attributable to the ammonium thiocyanate might have been due to ammonium sulphate itself, particularly where the conditions for its nitrification were not the best.

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[1] J. Pharm. Chim., 1893, XXVII, 190, cited from the Analyst.

[2] The Analyst, 1893, 18, p. 186.

The experiment was conducted in galvanized iron cans 8 inches in diameter and 14 inches deep. Each one had a small hole in the center of the bottom. A few chips of granite were placed in the bottom of each can and then each was filled with surface soil from land just north of the field used for the so-called soda substitution experiment. The fertilizers were mixed with the entire mass of the soil of each pot instead of being worked into the surface soil or being applied to the upper portion of the soil of each pot. For the purpose of checking the results some white commercial ammonium sulphate from another source which was known to contain no ammonium thiocyanate and also sodium nitrate were employed as sources of nitrogen in certain of the pots. Each pot received 6 grms. of dissolved boneblack and 2.5 grms. of muriate of potash and, excepting one pot, 2.5 grms. of ammonium sulphate or 4 grms. of sodium nitrate. The impure ammonium sulphate which contained the ammonium thiocyanate will be referred to for the sake of convenience as brown ammonium sulphate and the other as white. In certain pots air-slacked lime was employed at the rate of 18.4 grms. per pot and for the sake of brevity it is simply designated as lime in the table which follows. The pots were watered with well water as necessity required and were left out of doors during the entire experiment.

POT No.	EXPERIMENT WITH OATS.	Weight in grms. of total crop after air-drying in laboratory.
1	White ammonium sulphate....	24.3
2	" " " +lime....	31.2
3	" " " + .5 grms. am. thiocyanate..	20 8
4	" " " +1 grm. " " ..	7 6
5	Sodium nitrate+lime....	29.1
6	Lime, but no nitrogen in any form....	24.0
7	Brown ammonium sulphate....	24 4
8	" " "	24.0
9	" " " +lime....	30.4
10	" " " +lime....	31.6
11	" " " + .5 grms. am. thiocyanate	17.8
12	" " " + .5 " " " .	14.0

It will be seen that without lime the yield where the brown ammonium sulphate was used was practically the same as from the white lot, so that if any ill effect had resulted from the use of the white product it is obvious that the ill effect from the brown lot was no greater. In fact no positive ill effect was noticed in either case. Comparing the two kinds again it will be seen that where lime was used with each the results were practically the same, for we have 31.2 grms. from the white ammonium sulphate and 30.4 and 31.6 grms. from the brown, so that whether used with or without lime it gave results fully equal to the product which was free from ammonium thiocyanate. It will be seen, where ammonium thiocyanate was used in connection with the brown ammonium sulphate even with lime, that the yield was seriously affected. The same was likewise true where the thiocyanate was applied in connection with the white ammonium sulphate and lime and where the larger quantity was applied it will be seen that the weight of oats was but 7.6 grms. In view of the fact that the growth was excellent except where ammonium thiocyanate was added and in consideration of the fact that ammonium sulphate has always worked well upon this soil after liming, the poisonous action of ammonium thiocyanate upon plants is again demonstrated.

It will be seen from the above that sufficient ammonium thiocyanate may be present in ammonium sulphate to be readily detected yet without injury to crops, but where it is present in considerable quantities it exerts a highly poisonous action. Its effect seemed to be most serious upon the germination of the seeds, though the young plants were at first extremely yellow and sickly where it was used; yet after several days a few began to recover, took on a dark green color and made a fair growth.

CHEMICAL DIVISION.

H. J. WHEELER.

The work of the chemical division has been essentially the same in 1895 as it was in 1894, and owing to its varied character it will be described topically.

FERTILIZER INSPECTION.

The work of collecting samples of the fertilizers offered for sale in various parts of the State and the analysis of the same has devolved upon this division as usual. The work of collecting alone, has consumed the time of one man for more than a month. The total number of samples collected and analyzed in 1895 has been much greater than that in any previous year. They are divided as follows: Complete commercial fertilizers, one hundred and one; fine ground fish, one; nitrate of soda, two; muriate of potash, two; soluble "bone" and potash, one; unleached wood ashes, nine; fine ground bone, eight; tankage, one. The results of these analyses have been embodied in Station Bulletins, Nos. 32, 33 and 34, and compiled in a different form in an annual report to the State Board of Agriculture.

CONTINUATION OF INVESTIGATION OF METHODS OF POTASH DETERMINATION.

At the annual meeting of the Association of Official Agricultural Chemists in Washington, D. C., in August, 1894, the Station Chemist was re-appointed reporter on potash for the ensuing year, with A. L. Winton of Connecticut as associate. In connection with this work circular letters were sent to about fifty agricultural chemists soliciting their co-operation. From twenty to thirty sets of material were prepared, packed and shipped to various chemists who had expressed a willingness to assist in the investigation. In 1894 the comparative efficiency of the Lindo-Gladding and Alternate Methods had been tested in the presence of such impurities as are usually found in commercial fertilizers. In 1895 the investigation was conducted on essentially the same plan excepting that a larger quantity of sulphuric acid was introduced for the purpose of submitting the two methods to one of the most crucial tests likely to arise in ordinary practice.

These investigations have shown, in a decisive manner, the relative merits of the two methods under varying conditions. The results are embodied in the proceedings of the above mentioned association.* The investigations conducted by this Association from time to time have resulted in the adoption of methods which not only save much time but which are more accurate than many formerly in use, so that this work is of direct benefit to the Stations, not only in the execution of the analytical side of the fertilizer inspection but also in connection with all the routine analytical work conducted.

MISCELLANEOUS ANALYSES.

212. Fine Ground Kieserite, for the Station.
213. Epsom Salts, for the Station.

	212 Per cent.	213 Per cent.
Water	12.28	.....
Magnesia, (MgO)	21.11	16.17
Lime, (CaO)	2.66	.....

214. Dissolved Phosphate Rock.
215. Slag Meal.
216. Floats.

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* Bull. No. 46, U. S. Department of Agriculture, Division of Chemistry, Washington, D. C.

	214. Per cent.	*215.* Per cent.	*216.* Per cent.
Water	12.28	0.90	0.79
Soluble phosphoric acid	12.69	0.00	0.00
Reverted " "	1.82	8.09	1.70
Insoluble " "	.82	9.91	25.75
Total " "	15.33	18.00	27.45

217. Dissolved Boneblack.
218. Tankage or Animal Dust.

	217. Per cent.	*218.* Per cent.
Water	17.83	12.44
Soluble phosphoric acid	11.31	.13
Reverted " "	5.06	4.71
Insoluble " "	3.47	7.59
Total " "	19.84	12.43
Nitrogen	.....	6.28

219. Leather, for the Station.
220. Dried Blood, for the Station.
221. Sulphate of Ammonia, for the Station.
222. Nitrate of Soda, for the Station.

	219. Per cent.	*220.* Per cent.	*221.* Per cent.	*222.* Per cent.
Water	10.13	21.88	0.41	0.19
Nitrogen	7.06	9.17	19.67	15.33

223. Double Superphosphate, for the Station.
224. Fine Ground Bone, for the Station.

	223. Per cent.	*224.* Per cent.
Water	8.16	3.59
Nitrogen	.....	2.04
Soluble phosphoric acid	27.35	.06
Reverted " "	17.29	20.76
Available " "	44.64	20.82
Insoluble " "	.86	6.29
Total " "	45.50	27.11

Mechanical analyses of the above bone.

	Per cent.
Finer than 1-50 inch (fine)	63.63
" " 1-25 " (fine medium)	20.87
" " 1-12 " (medium)	14.95
Coarser than 1-12 inch (coarse)	.55
	100.00

225. Wood Ashes, from W. E. Hopkins, North Scituate.
226. " " Rowland Hazard, Peacedale.
227. Lime-Kiln Ashes, from O. H. J. Perry, Jr., Providence.
228. " " " " George H. Gates, West Kingston.

	225.	*226.*	*227.*	*228.*
	Per cent.	Per cent.	Per cent.	Per cent.
Water	6.29	11.62	3.44	*
Phosphoric acid	1.42	0.85	2.02	*
Potash	7.82	4.18	1.85	0.75
Lime, (CaO)	*	*	43.66	41.17

229. Muriate of Potash, for the Station.
230. Carbonate of Potash, for the Station.

	229.	*230.*
	Per cent.	Per cent.
Water	0.79	*
Potash	52.52	57.16

231. Air-slacked Lime, for the Station.
232. " " from Geo. H. Gates, West Kingston.

	231.	*232.*
	Per cent.	Per cent.
Lime, (CaO)	75.24	55.16

233. Land Plaster (gypsum), for the Station.

	233.
	Per cent.
Water at 100° C.	8.84
Water at red heat	5.50
Lime (CaO)	38.34
Magnesia (MgO)	Trace.

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*Not determined.

234. Wood ashes from L. F. Waterman, Manton, R. I.

	234. Per cent.
Water	8.59
Phosphoric acid	1.45
Potash	5.82

235 and 236. Muck and clay, (two samples), from B. A. Winsor, Harmony, R. I.

	235. Per cent.	*236.* Per cent.
Water	1.12	6.71
Phosphoric acid	.10	.29
Nitrogen	.15	.76
Lime (CaO)	Trace.	Trace.

Sample No. 235 has no particular value, and Sample No. 236 contains only about half as much nitrogen as meadow muck, which constitutes practically its only value.

FIELD AND POT EXPERIMENTS.

The work in connection with field and pot experiments conducted in coöperation with the Agricultural Division has occupied much of my time during the past year. The experiments have been chiefly a continuation of those outlined in the report for 1894. An enumeration of them may be found in the report of the Director on page 178.

CORRESPONDENCE, PUBLICATIONS, ETC.

The amount of the correspondence in connection with the work of the Chemical Division has been much greater during 1895 than it was in 1894. The number of applications from farmers for fertilizer formulas became so great during the year that the publication of a special article on home-mixed fertilizers which should embrace special formulas for various purposes, seemed advisable. The amount of correspondence has also been somewhat increased by the collection of data in relation to home-mixed fertilizers, and by correspondence involved in the investigation of methods of potash determination heretofore mentioned.

The publications issued by the Chemical Division during the year are the following:

Bulletin 32, June. "Analyses of Commercial Fertilizers." 11 pp., by H. J. Wheeler, B. L. Hartwell and C. L. Sargent.

Bulletin 33, October. "Fertilizers." 15 pp., by H. J. Wheeler, B. L. Hartwell and C. L. Sargent. "The Effect of Liming upon the Development of Potato Tubers." 5 pp., by H. J. Wheeler, J. D. Towar and G. M. Tucker. "Upon the Effect of Barnyard Manure and Various Compounds of Sodium, Calcium and Nitrogen upon the Development of the Potato Scab." 29 pp., by H. J. Wheeler and G. M. Tucker.

Bulletin 34, December. "Analyses of Commercial Fertilizers." 7 pp., by H. J. Wheeler, B. L. Hartwell and C. L. Sargent. "Home-Mixed Fertilizers." 37 pp., by H. J. Wheeler and B. L. Hartwell.

In addition to the paper on methods of potash determination previously referred to, a paper was also prepared and read by H. J. Wheeler at the annual meeting of the Official Association of Agricultural Chemists, on "The Necessity for Tests for Acidity in Upland or Naturally Well-Drained Soils." In addition to the above, six lectures have been delivered under the auspices of the State Board of Agriculture, stenographic reports of which have been prepared for publication in the report of that body. The same publication also contains an annual report of the work of this division in connection with the State fertilizer inspection. The other articles prepared for publication during the year are embodied in this report.

Attention must be called once more to the fact that sufficient room is not afforded in the narrow quarters alloted for use as a chemical laboratory, for either the satisfactory or the most economical execution of the work to be done.

To my assistants, Mr. B. L. Hartwell and Mr. C. L. Sargent, is due much credit for the part which they have taken in the work of the division. They have been most faithful in the discharge of whatever duties have been assigned to them. Mr. Hartwell particularly has rendered much and valuable assistance in connection with the work of the division aside from that performed in the chemical laboratory. I take particular pleasure in thanking both of these gentlemen for their hearty support and coöperation in everything pertaining to the welfare of the division and to the Station as a whole.

ANALYSES OF WATER SENT FOR EXAMINATION.

(PARTS PER MILLION).

NUMBER.	PARTY SENDING, AND LOCALITY.		DATE OF ANALYSIS	FREE AMMONIA.	ALBUMINOID AMMONIA.	CHLORINE.	REMARKS.
237	E. Walker	Wakefield	Jan. 14.	.24	.21	19.0	Bad.
238	J. H. Wells	Kingston	Jan. 24.	.04	.12	50.0	Suspicious.
239	C. L. Brine	Kingston.	Jan. 24.	.05	.06	7.0	Good.
240	M. E. Sargent	Peacedale.	Jan. 23.	.07	.14	29.0	Suspicious.
241	A. W. Flanders	Pawtucket	Feb. 15.	.04	.05	7.0	Good.
242	J. T. Burdick	Newport	Apr. 20.	08	.12	53.0	Suspicious.
243	Melville Bull	Newport	Aug. 20.	.07	.10	19.0	Fair.
244	James McArdle	Peacedale*	Sept. 26.	.41	.34	2.0	Bad.
245	Gardiner C. Sims.	Providence	Nov. 14.	.13	.11	25.0	Very suspicious.
246	H. L. Perry	Peacedale	Nov. 18.	.10	.14	4.0	Suspicious.
247	H. B. Ellis	East Greenwich	Dec. 16.	.05	20	14.0	Suspicious.
248	Griffin & Browning.	Narragansett Pier†	June 22.	21	.16	2.0	Bad.

* Cistern water. † Mostly surface water as shown by the small amount of chlorine.

HORTICULTURAL DIVISION.

HEATING GREEN-HOUSES.

A TRIAL OF 4 IN. CAST IRON AND 1¼ IN. WROUGHT IRON PIPE FOR THE CIRCULATION OF HOT WATER.

L. F. KINNEY AND G. E. ADAMS.

Although steam is now generally used for heating all large commercial green-houses, hot water is still preferred for heating smaller houses and conservatories. Both the cast and the wrought iron pipes are in common use for the circulation of the water, and the owners of green-houses are by no means agreed upon the relative merits of each for the purpose. The principal advantages claimed for the small pipe system of heating, which is the newer of the two, are that more variation in the arrangement of the pipes is practicable and that the temperature in a house where the small pipes are used is more perfectly under the control of the person in charge of the heater than that in a similar house where the large pipes are used.

On the other hand it is claimed that if the heater in a green-house is not to receive close attention it is safer to use the large pipes. If these claims are granted, then the following questions may arise:

(1) Is the night temperature as uniform in a house that is heated with the small pipes as in one that is heated with the large pipes?

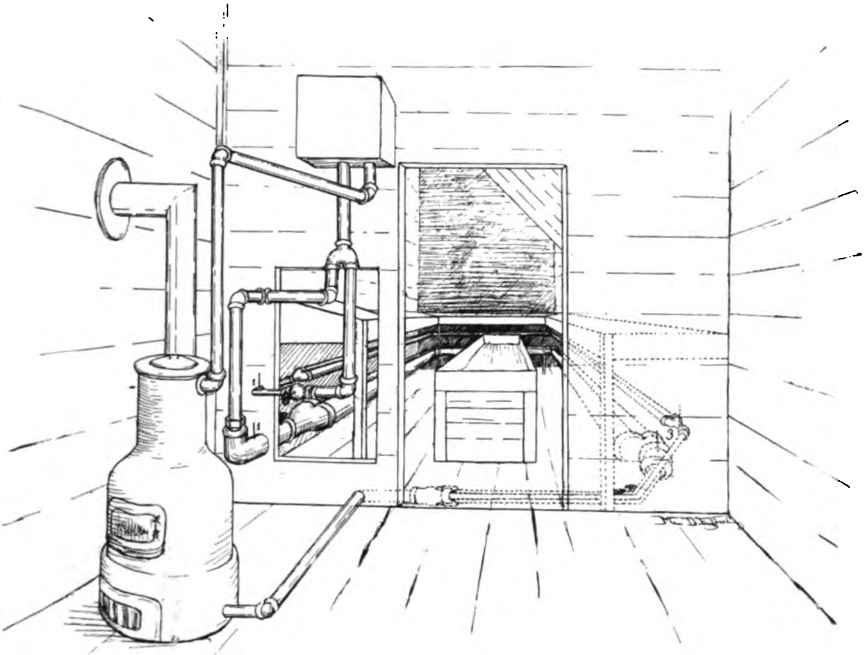
(2) Is more or less fuel required to heat a house with the small pipes?

(3) Is the humidity of the atmosphere appreciably different when either kind of pipe is used?

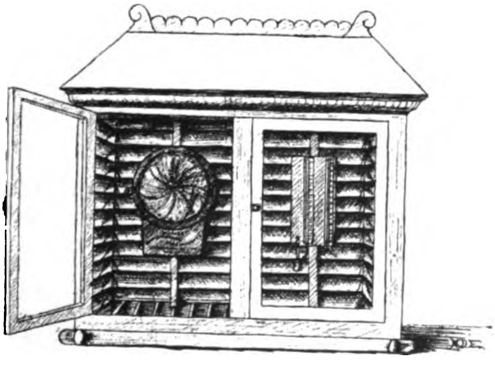
The results of the trial, which are given in the following pages, show that with the same attention a heater maintained a higher temperature in a house when the water circulated in a system of large pipes than when it circulated in a similar system of small pipes, but that in doing this more coal was burned. The small pipes did not sustain the temperature during the last half of the night quite as well as the large ones. Between 2½ and 2¾ pounds of coal were burned for each degree of difference between the outside temperature and that in the house during the trial and this varied but little when either system of the pipes was used. The atmosphere in the house was not quite as dry during the use of the small pipes as when the other system was in use.

HOUSE IN WHICH THE TRIAL WAS MADE.

This was a small lean-to structure 11 x 30 ft. The walks were about 3 ft. below the level of the ground and the benches were made of wood. One of the benches exended around the outside of the house and another narrow one was in the center. Upon the central bench and 12 ft. from the end of the house farthest from the heater a wooden slat thermometer shelter was placed with the glass doors on the north side so that no direct sunlight would be admitted. In the shelter a Draper self-recording thermometer and wet and dry bulb standard thermometers were fastened to supports. The only ventilators in the greenhouse were at the top of the roof, and care was taken in managing the fire in the heater so that it was necessary to open these but little.



HEATER AND ARRANGEMENT OF PIPES.



THERMOMETER SHELTER.

HEATER AND ARRANGEMENT OF PIPES.

The heater used was a Hitching's Base Burner, No. 23, with an expansion tank about 3 ft. above it. Two lines of 4 in. cast iron and two lines of 1½ in. wrought iron pipe were placed beneath the outside bench as shown in the figure. There were the same number of feet of each kind of pipe and the lines were parallel, the small pipes being about 8 in. above the large. The two systems were connected with the expansion tank above the heater as shown in the figure. After entering the green-house proper the pipes were placed on a gradual decline, arriving at and being connected with the heater near its base. Valves were placed in the pipes as shown in the figure so that either system conld be used entirely independent of the other.

PLAN OF THE TRIAL.

The large and small pipes were used on alternate days, the change from one to the other being made at noon, a time of as little importance as any in the records on account of the influence of the sunlight upon the temperature. At the time the valves were changed the water was drawn from the heater and the pipes and they were refilled with cold water from the hydrant. Either an entirely new fire was made in the heater or the old fire was shaken down until only a thin layer of live coals remained upon the grate sufficient to kindle fresh coal. Records were made of the weight of coal burned each day and the amount of ashes, slate and clinkers taken from the heater. Anthracite coal, chestnut size, was used so that it would not clog in the reservoir of the heater. The records of the temperature were continuous throughout the twenty-four hours, those of the readings of the wet and dry bulb thermometers were made at 2 and 9 P. M. and at 8 A. M. The time during which the trial continued is divided into four periods. In the January period there were 10 days, in the two February periods 14 days each, and in the March period 18 days.

TEMPERATURE AND COAL RECORDS.

JANUARY PERIOD.

DAYS WHEN THE SMALL PIPES WERE USED.

Date.	Temperature outside of house.				Temperature in house.				Pounds Coal.
	6 P. M.	9 P. M.	12 night.	6 A. M.	6 P. M.	9 P. M.	12 night.	6 A. M.	
Jan. 14........	29	28	26	20	64	61	60	57	112
" 16........	35	34	33	29	61	58	55	55	80
" 18........	29	27	26	25	62	59	57	56	70
" 20........	28	23	23	24	71	68	62	58	75.5
" 22........	36	34	30	26	70	64	60	56	88

JANUARY PERIOD.

DAYS WHEN THE LARGE PIPES WERE USED.

Date.	Temperature outside of house.				Temperature in house.				Pounds Coal.
	6 P. M.	9 P. M.	12 night.	6 A. M.	6 P. M.	9 P. M.	12 night.	6 A. M.	
Jan. 15........	33	31	30	33	68	65	63	63	99
" 17........	33	30	27	23	66	62	62	61	105
" 19........	23	20	18	12	57	60	60	60	119
" 21........	36	39	42	41	57	62	67	65	95
" 23........	29	25	22	16	63	61	60	61	94.5

FIRST FEBRUARY PERIOD.

DAYS WHEN THE SMALL PIPES WERE USED.

Date.	Temperature outside of house.				Temperature in house.				Pounds Coal.
	6 P. M.	9 P. M.	12 night.	6 A. M.	6 P. M.	9 P. M.	12 night.	6 A. M.	
Feb. 2........	31	28	21	11	60	58	56	52	90
" 4........	27	23	19	11	64	61	56	50	94
" 6...	11	9	8	5	69	58	55	53	131
" 8........	4	2	2	3	59	52	58	57	155
" 10........	27	24	24	21	65	60	57	53	105
" 12........	29	26	25	24	67	63	62	59	104
" 14........	34	30	27	23	73	63	61	53	102

FIRST FEBRUARY PERIOD.

DAYS WHEN THE LARGE PIPES WERE USED.

Date.	Temperature outside of house.				Temperature in house.				Pounds Coal.
	6 P. M.	9 P. M.	12 night.	6 A. M.	6 P. M.	9 P. M.	12 night.	6 A. M.	
Feb. 1.	30	30	30	29	66	65	65	61	84.5
" 3........	25	26	26	25	62	66	64	59	114
" 5........	8	4	2	—1	68	61	60	48	169
" 7........	15	15	24	26	57	57	58	61	144
" 9........	17	17	18	16	66	65	64	60	138
" 11........	30	24	21	18	67	64	65	60	88
" 13........	30	26	21	23	59	58	58	55	66

SECOND FEBRUARY PERIOD.

DAYS WHEN THE SMALL PIPES WERE USED.

Date.	Temperature outside of house.				Temperature in house.				Pounds Coal.
	6 P. M.	9 P. M.	12 night.	6 A M.	6 P. M.	9 P. M.	12 night.	6 A. M.	
Feb. 16........	31	29	26	26	58	50	49	47	105
" 18........	31	29	29	28	64	59	58	58	79
" 20........	30	26	23	28	64	55	51	50	87
" 22........	22	18	15	11	60	53	49	46	73
" 24........	25	22	23	27	60	52	49	46	77.5
" 26........	23	20	17	14	55	48	55	44	98.5
" 28........	39	37	37	33	60	54	58	54	52

SECOND FEBRUARY PERIOD.

DAYS WHEN THE LARGE PIPES WERE USED.

Date.	Temperature outside of house.				Temperature in house.				Pounds Coal.
	6 P. M.	9 P. M.	12 night.	6 A. M.	6 P. M.	9 P. M.	12 night.	6 A. M.	
Feb. 15........	37	30	27	24	68	62	57	51	108
" 17........	33	33	31	26	66	56	55	48	61
" 19........	33	28	27	27	68	59	58	55	70.5
" 21........	33	30	31	27	58	56	54	56	96
" 23........	23	20	17	10	68	58	50.5	47	96
" 25........	34	34	35	28	62	59	58	51	85.5
" 27........	31	27	27	26	55	50	52	56	64

March Period.

DAYS WHEN THE SMALL PIPES WERE USED.

Date.	Temperature outside of house.				Temperature in house.				Pounds Coal.
	6 P. M.	9 P. M.	12 night.	6 A. M.	6 P. M.	9 P. M.	12 night.	6 A. M.	
Mar. 2.......	33	33	32	29	51	58	58	51	92
" 4.......	37	39	36	18	52	58	57	50	76
" 6.......	33	34	33	35	56	58	52	52	58
" 8.......	38	36	34	33	61	58	56.5	50	43
" 10.......	40	35	34	30	61	55	53	48	34
" 12.......	32	30	31	30	55	52	51	53	42
" 14.......	37	30	27	22	54	55	51	48	55
" 16.......	30	25	24	19	62	56	50	48	68
" 18.......	33	31	30	27	63	57	53	50	79

March Period.

DAYS WHEN THE LARGE PIPES WERE USED.

Date.	Temperature outside of house.				Temperature in house.				Pounds Coal.
	6 P. M.	9 P. M.	12 night.	6 A. M.	6 P. M.	9 P. M.	12 night.	6 A. M.	
Mar. 1.......	41	37	37	38	63	59	58	59	40
" 3.......	32	29	28	30	60	54	56	58	76
" 5.......	23.5	21	19	17	52	50	50	52	87
" 7.......	40	38	34	35	54	54	51.5	51	54
" 9.......	35	30	30	30	60	51	49	45	48
" 11.......	30	29	28	28	51	49	48	46	43
" 13.......	35	34	37	37	52	51	54	54	48
" 15.......	23	24	24	25	50	53	52	50	62
" 17.......	32	30	30	28	62	53	52	54	96

During the trial the water circulated 28 days in each kind of pipe and the temperature in the house was as high or higher when the small pipes were used as at corresponding time when the large pipes were used as follows:

At 6 P. M.	19 of the 28 days.
At 9 P. M.	9 " "
At 12 night	11 " "
At 6 A. M.	3 " "

The outdoor records show that the temperature was as high or higher at the different hours during the days when the small pipes were used as follows:

At 6 P. M.	17 of the 28 days.
At 9 P. M.	16 " "
At 12 night	16 " "
At 6 A. M.	14 " "

From these figures it appears that the small pipes warmed the atmosphere in the house certainly as quickly after the fire was started in the afternoon as the large, but that the large pipes usually kept the house warmer towards morning than the small ones.

AVERAGE TEMPERATURES IN THE HOUSE DURING THE TRIAL.

1½ IN. WROUGHT IRON PIPES.		4 IN. CAST IRON PIPES.
	6 P. M.	
59.68		60.79
	9 P. M.	
56.98		58.52
	12 NIGHT.	
55 39		57.39
	6 A. M.	
52.39		55.95

These figures show that the temperature averaged higher at each of the four times of which records are given when the hot water circulation was in the large pipes. The difference in favor of the large pipes being as follows:

At 6 P. M.	1.1	degrees.
At 9 P. M.	1.5	"
At 12 night	2.0	"
At 6 A. M.	3.5	"

COAL USED FOR EACH DEGREE OF DIFFERENCE BETWEEN THE AVERAGE OUTSIDE AND INSIDE TEMPERATURES.

Less coal was burned with the small pipes than with the large, but as already shown, the average temperature in the house was not as high during the nights that the small pipes were used, and also the average outside temperature was not exactly the same during the trial of both kinds of pipe. The real efficiency of each system, therefore, for heating the greenhouse so far as fuel is concerned must be determined by considering the difference between the outside and inside temperature during the trial, together with the coal burned with each system. Following is a summary of average temperatures and coal records for the four periods;

January Period—January 14th to January 25th.

	Average temperature in house.		Average temperature outside.		Average weight of coal burned per day.		Average weight of coal required to maintain each degree of temperature in the house above that outside for the 24 hours.	
	During trial of 1⅛ in. pipes.	During trial of 4 in. pipes.	During trial of 1⅛ in. pipes.	During trial of 4 in. pipes.	During trial of 1⅛ in. pipes.	During trial of 4 in. pipes.	During trial of 1⅛ in. pipes.	During trial of 4 in. pipes.
6 P.M.	65.60	62.20	31.60	29.00				
9 P.M.	61.00	62.00	29.20	29.00				
12 night	58.80	60.40	27.60	27.80				
6 A.M.	56.40	62.00	24.80	25.00				
12 noon	73.60	73.40	32.20	30.80	lbs.	lbs.	lbs.	lbs.
Average	63.48	64.00	29.08	28.32	85.10	102.50	2.47	2.87

SUMMARY—CONTINUED.

	Average temperature in house.		Average temperature outside.		Average weight of coal burned per day.		Average weight of coal required to maintain each degree of temperature in the house above that outside for the 24 hours.	
	During trial of 1½ in. pipes.	During trial of 4 in. pipes.	During trial of 1⅛ in. pipes.	During trial of 4 in. pipes.	During trial of 1⅛ in. pipes.	During trial of 4 in. pipes.	During trial of 1⅛ in. pipes.	During trial of 4 in. pipes.
First February Period—February 1st to February 15th.								
6 P.M.	65.28	68.57	28.28	22.14				
9 P.M.	59.28	62.28	20.26	20.28				
12 night	57.85	62.00	18.00	20.28				
6 A.M.	54.60	57.70	14.00	19.42				
12 noon	78.71	80.14	21.00	28.14				
Average	62.14	65.18	19.81	21.05	lbs. 111.57	lbs. 114.78	lbs. 2.60	lbs. 2.60
Second February Period—February 15th to March 1st.								
6 P.M.	59.42	61.42	28.71	32.71				
9 P.M.	58.00	57.14	25.57	28.85				
12 night	52.00	54.92	24.28	27.85				
6 A.M.	48.57	52.00	28.15	24.00				
12 noon	69.42	78.14	31.85	30.71				
Average	56.48	59.72	26.71	28.82	lbs. 81.00	lbs. 82.22	lbs. 2.72	lbs. 2.66
March Period—March 1st to March 19th.								
6 P.M.	57.22	56.00	34.77	32.88				
9 P.M.	54.66	52.66	32.55	30.22				
12 night	52 94	52.27	31.22	29.66				
6 A.M.	50.00	52.11	27.00	29.77				
12 noon	51.11	56.55	36.00	34.66				
Average	53.18	53.91	32.30	31.33	lbs. 60.88	lbs. 61.55	lbs. 2.91	lbs. 2.72
Grand average	58 32	60.69	26.88	27.45	84.68	90.26	2.67	2.71

From 2½ to 2¾ lbs. of coal were burned for each degree of difference between the average outside and inside temperatures during the trial, and it made but little difference in which kind of pipe the water circulated. It should be noted in this connection that colder weather prevailed during the first period in February than at any other time during the trial, and that during this time exactly the same amount of coal was burned with each kind of pipe to maintain each degree of difference between the average outside and inside temperatures.

RELATIVE HUMIDITY OF THE ATMOSPHERE.

The presence of a certain amount of moisture in the air is necessary for the successful growth of plants. It is often stated that small pipes, because they are heated to a higher temperature, produce a dryer atmosphere than large ones. Such was not the case during this trial.

Following are the records for the four periods:

RELATIVE HUMIDITY.—JANUARY PERIOD.

1¼-Inch Wrought Iron Pipes.				4-Inch Cast Iron Pipes.			
Date.	8 A. M.	12 M.	9 P. M.	Date.	8 A. M.	12 M.	9 P. M.
Jan. 14..........	80 per ct.	68 per ct.	74 per ct.	Jan. 15..........	80 per ct.	78 per ct.	78 per ct.
" 16..........	80 "	84 "	86 "	" 17..........	74 "	47 "	78 "
" 18..........	88 "	61 "	88 "	" 19..........	80 "	84 "	74 "
" 20..........	80 "	47 "	78 "	" 21..........	81 "	68 "	84 "
" 22..........	80 "	53 "	75 "	" 23..........	78 "	37 "	69 "

RELATIVE HUMIDITY.—FIRST FEBRUARY PERIOD.

1¼-Inch Wrought Iron Pipes.				4-Inch Cast Iron Pipes.			
Date.	8 A. M.	12 M.	9 P. M.	Date.	8 A. M.	12 M.	9 P. M.
Feb. 2..........	77 per ct.	86 per ct.	69 per ct.	Feb. 1..........	74 per ct.	48 per ct.	78 per ct.
" 4..........	77 "	74 "	63 "	" 3..........	80 "	45 "	63 "
" 6..........	72 "	42 "	66 "	" 5..........	60 "	45 "	62 "
" 8..........	66 "	42 "	74 "	" 7..........	71 "	42 "	61 "
" 10..........	71 "	32 "	66 "	" 9..........	69 "	58 "	65 "
" 12..........	80 "	46 "	75 "	" 11..........	70 "	39 "	65 "
" 14..........	80 "	44 "	74 "	" 13..........	74 "	80 "	77 "

RELATIVE HUMIDITY.—SECOND FEBRUARY PERIOD.

1½-Inch Wrought Iron Pipes.				4-Inch Cast Iron Pipes.			
Date.	8 A. M.	12 M.	9 P. M.	Date.	8 A. M.	12 M.	9 P. M.
Feb. 16..........	74 per ct.	62 per ct.	74 per ct.	Feb. 15..........	74 per ct.	48 per ct.	74 per ct.
" 18..........	80 "	54 "	78 "	" 17..........	70 "	48 "	72 "
" 20..........	80 "	42 "	74 "	" 19..........	80 "	44 "	78 "
" 22..........	80 "	43 "	80 "	" 21..........	80 "	74 "	80 "
" 24..........	86 "	41 "	80 "	" 23..........	80 "	53 "	70 "
" 26..........	77 "	47 "	80 "	" 25..........	80 "	46 "	78 "
" 28..........	80 "	76 "	86 "	" 27..........	80 "	74 "	80 "

RELATIVE HUMIDITY—MARCH PERIOD.

1½-inch Wrought Iron Pipes.				4-inch Cast Iron Pipes.			
Date.	8 A.M.	12 M.	9 P.M.	Date.	8 A.M.	12 M.	9 P.M.
March 2.	86 per ct.	80 per ct.	86 per ct.	March 1.	74 per ct.	87 per ct.	87 per ct.
" 4.	80 "	84 "	80 "	" 3.	74 "	80 "	74 "
" 6.	84 "	66 "	80 "	" 5.	80 "	66 "	80 "
" 8.	80 "	87 "	87 "	" 7.	86 "	75 "	86 "
" 10.	80 "	70 "	93 "	" 9.	86 "	93 "	74 "
" 12.	93 "	86 "	86 "	" 11.	86 "	72 "	90 "
" 14.	80 "	66 "	86 "	" 13.	86 "	86 "	86 "
" 16.	86 "	81 "	80 "	" 15.	86 "	86 "	86 "
" 18.	86 "	62 "	80 "	" 17.	80 "	62 "	80 "

Altogether 168 records of the humidity of the air in the greenhouse were made during the trial of the two kinds of pipe; one-half of these, or 84 records, being made during the use of the 1½ inch wrought iron pipe. From these records it appears that at 55 of the 84 times, the relative humidity of the air was as high or higher during the use of the small pipes as at corresponding hours during the days when large pipes were used. These were divided between the different hours as follows:

21 of the 28 records at 8 A. M.
15 “ “ “ “ 12 noon.
19 “ “ “ “ 9 P. M.

The average relative humidity for the different hours was as follows:

January 14th to January 25th.

	House heated by small pipes.	House heated by large pipes.
8 A. M.	80.6 per cent	77.4 per cent.
12 noon	62.6 “	61.8 “
9 P. M.	78.0 “	75.6 “
Average	72.4 “	71.6 “

February 1st to February 15th.

	House heated by small pipes.	House heated by large pipes.
8 A. M.	74.7 per cent	71.1 per cent.
12 noon	52.3 “	50.2 “
9 P. M.	69.5 “	66.5 “
Average	65.5 “	62.6 “

February 15th to March 1st.

	House heated by small pipes.	House heated by large pipes.
8 A. M.	79.5 per cent	77.7 per cent.
12 noon	52.1 “	55.2 “
9 P. M.	78.8 “	76.0 “
Average	70.1 “	69.6 “

March 1st to March 19th.

	House heated by small pipes.	House heated by large pipes.
8 A. M.	83.9 per cent	82.0 per cent.
12 noon	75.7 “	78.5 “
9 P. M.	84.2 “	82.5 “
Average	81.2 “	82.1 “

If the noon records which were influenced more than the others by sunlight, ventilation, etc., were not included in the averages in the different periods, they would show that the relative humidity averaged 2½° higher during the use of the small pipes than it did during the use of the large pipes. From this it is evident that when the house was heated by the 1½ inch wrought iron pipes the air in it was not as dry as when it was heated by the 4 inch cast iron pipes. It should be noted here that the temperature in the house averaged a little lower during that part of the trial in which the small pipes were used, and this fact may have had some influence upon the relative humidity of the atmosphere, although it hardly seems probable that so little difference in temperature would have made as much difference in the relative amount of moisture in the air.

TABLES SHOWING THE TIME REQUIRED TO HEAT UP EACH SYSTEM OF THE PIPES.

1½-inch Wrought Iron Pipes.

	No fire.	Fire 15 minutes.	Fire 30 minutes.	Fire 45 minutes.	Fire 1 hour.	Fire 1¼ hours.	Fire 1½ hours.
Time	2.00 P.M.	2.15 P.M.	2.30 P.M.	2.45 P.M.	3.00 P.M.	3.15 P.M.	3.30 P.M.
Thermometer No. 1	61°	70°	100°	126°	171°	207°	212°
Thermometer No. 2	48°	56°	84°	109°	151°	194°	210°
Thermometer No. 3	46°	50°	64°	95°	129°	181°	206°

4-inch Cast Iron Pipes.

	No fire.	Fire 15 minutes.	Fire 30 minutes.	Fire 45 minutes.	Fire 1 hour.	Fire 1¼ hours.	Fire 1½ hours.	Fire 1¾ hours.	Fire 2 hours.	Fire 2¼ hours.	Fire 2½ hours.	Fire 2¾ hours.
Time	10.00 A.M.	10.15 A.M.	10.30 A.M.	10.45 A.M.	11.00 A.M.	11.15 A.M.	11.30 A.M.	11.45 A.M.	12.00 M.	12.15 P.M.	12.30 P.M.	12.45 P.M.
Th'mometer No. 1	91°	100°	108°	120°	140°	162°	181°	196°	201°	208°	210°	212°
Th'mometer No. 2	61°	68°	77°	91°	108°	129°	151°	167°	181°	192°	199°	205°
Th'mometer No. 3	cold*	cold*	cold*	cold*	cold*	97°	118°	134°	154°	172°	192°	201°

* Inserted into the tube so that it could not be read below 80°.

TABLES SHOWING THE COMPARATIVE RAPIDITY WITH WHICH EACH SYSTEM OF PIPES COOLED OFF AFTER THE FIRE WAS TURNED DOWN.

1½-Inch Wrought Iron Pipes.

	Fire drawn.	No fire ½ hour.	No fire 1 hour.	No fire 1½ hours.	No fire 2 hours.	No fire 2½ hours.	No fire 3 hours.	No fire 3½ hours.	No fire 4 hours.	No fire 4½ hours.	No fire 5 hours.
Time	11.45 A.M.	12.15 P.M.	12.45 P.M.	1.15 P.M.	1.45 P.M.	2.15 P.M.	2.45 P.M.	3.15 P.M.	3.45 P.M.	4.15 P.M.	4.45 P.M.
Thermometer No. 1	192°	142°	122°	104°	93°	86°	81°	77°	73°	72°	72°
Thermometer No. 2	169°	133°	115°	97°	84°	81°	77°	72°	70°	66°	66°
Thermometer No. 3	162°	127°	106°	91°	82°	79°	75°	70°	66°	64°	64°

4-Inch Cast Iron Pipes.

	Fire drawn.	No fire ½ hour.	No fire 1 hour.	No fire 1½ hours.	No fire 2 hours.	No fire 2½ hours.	No fire 3 hours.	No fire 3½ hours.	No fire 4 hours.	No fire 4½ hours.	No fire 5 hours.	No fire 5½ hours.
Time.	11.45 A.M.	12.15 P.M.	12.45 P.M.	1.15 P.M.	1.45 P.M.	2.15 P.M.	2.45 P.M.	3.15 P.M.	3.45 P.M.	4.15 P.M.	4.45 P.M.	5.15 P.M.
Th'mometer No. 1	198°	167°	147°	131°	115°	106°	99°	93°	88°	82°	81°	79°
Th'mometer No. 2	154°	158°	136°	122°	113°	104°	97°	91°	88°	82°	81°	79°
Th'mometer No. 3	129°	125°	118°	108°	100°	95°	90°	79°	Cold*	Cold*	Cold*	Cold*

Temperature of House.

Time	11.45 A.M.	12.15 P.M.	12 45 P.M.	1.15 P.M.	1.45 P.M.	2.15 P.M.	2.45 P.M.	3.15 P.M.	3.45 P.M.	4.15 P.M.	4.45 P.M.
Temperature	79°	61°	71°	72°	64°	64°	64°	64°	64°	63°	62°

* Inserted into the tube so that it could not be read below 80°.

TABLES SHOWING THE TEMPERATURES OF THE OUTSIDE OF EACH KIND OF PIPE AND THAT OF THE WATER WITHIN AT THE SAME POINT.

1½-inch Wrought Iron Pipes.

	Thermometer No. 1.		Thermometer No. 2.		Thermometer No. 3.	
	Inside of pipe.	Outside of pipe.	Inside of pipe.	Outside of pipe.	Inside of pipe.	Outside of pipe.
2.45 P.M.	172	140	138	115	108	90
3.00 P.M.	169	135	154	131	147	127
3.15 P.M.	190	163	176	158	171	149
3.30 P.M.	203	176	199	172	196	172
3.45 P.M.	208	181	206	181	208	182
4 00 P.M.	207	180	196	169	189	167
4.15 P.M.	187	163	169	144	160	149
4.30 P.M.	172	151	154	136	147	127
Average difference..	27.4		23.5		19 2	

4-inch Cast Iron Pipes.

	Thermometer No. 1.		Thermometer No. 2.		Thermometer No. 3.	
	Inside of pipe.	Outside of pipe.	Inside of pipe.	Outside of pipe.	Inside of pipe.	Outside of pipe.
11.15 A.M.	190	144	151	129	120	106
11.30 A.M.	192	154	158	135	129	113
11.45 A.M.	187	149	156	133	131	113
12.00 noon	188	149	158	135	136	120
1.00 P.M.	183	140	156	131	138	117
1.15 P.M.	183	145	156	133	138	117
1.30 P.M.	185	145	158	135	142	122
1.45 P.M.	192	154	165	140	145	123
2.00 P.M.	199	158	176	144	156	133
Average difference..	39.4		24.3		19.0	

SUMMARY.

(1.) The radiating surface of the small pipes was sufficient to heat the house. This was proved during the night of February 8th, when the temperature outside of the house dropped to near zero.

(2.) The attention given the heater was the same with each kind of pipe, it rarely being visited later than nine or ten o'clock during the night. But it is evident that more heat was radiated into the house by the large than by the small pipes. This fact was particularly noticeable during the last half of the night.

(3.) Less coal was burned during the trial of the small pipes, but the temperature in the house was correspondingly lower during this time than it was when the water circulated in the large pipes.

(4.) Practically the same weight of coal was required by each system of pipes to maintain each degree of temperature in the house above that outside.

(5.) For a lettuce or violet house the temperature produced by the small pipes would be preferred to that produced by the large, but for plants requiring a high night temperature the reverse would be true.

(6.) The air in the house was not quite as dry during the use of the small as during the use of the large pipes.

(7.) With a new fire in the heater it took nearly twice as long to heat up the system of large pipes as was required to heat up the system of small pipes. This is shown by the tables on page 307.

(8.) The small pipes cooled off more rapidly than the large after the fire was drawn. See tables, page 308.

(9.) There was more difference between the temperature of the outside of the pipe and that of the water within where thermometer No. 1 was placed in the large than in the small pipes, but at the other two points the difference averaged about the same with both kinds of pipe.

(10.) The cost of the wrought and cast iron pipe per square foot of radiating surface is generally estimated about the same by dealers in greenhouse heating materials. Of the two perhaps the advantage would be in favor of the former.

(11.) In this trial there was only about one-half as much radiating surface of the small pipe as there was of the large, therefore the wrought iron system cost less than the other, although it might have been better if more of the small pipe had been used.

(12.) Two inch wrought iron pipe seems to be preferred to the smaller size for heating greenhouses because it is believed that water circulates more freely in it.

AGRICULTURAL DIVISION.

INDIAN CORN EXPERIMENTS.

CHAS. O. FLAGG AND GEO. M. TUCKER.

During the season of 1894 four varieties of Western field corn (Dent varieties) were grown on the Station farm, and in order to obtain some comparative value of these varieties it was determined to secure, if possible, reliable results as to their relative degrees of shrinkage in the crib. For this purpose, on the 23d of November, 1894, five varieties of corn, including Rhode Island Capped corn (a white flint variety), were weighed out in quantities of twenty-five pounds each of average mature ears and placed in the corn crib, secured from the invasion of rats by being hung in sacks and left to dry until March 25, 1895, or during a period of four months.

The following table gives the result of the test:

NAME OF VARIETY.	Weight. November.	Weight. March 25.	Shrinkage.	Weight of Shelled Corn.	Per cent Shelled Corn.	Per cent. Cob.
	1894. lbs.	1895. lbs.	Per cent.	Mar. 25, 1895.		
Rhode Island Capped, White Flint....	25	20.00	20.	17.25	86.25	13.75
Huron Pure Yellow, Dent.............	25	19.75	21.	16.00	81.01	18.99
Minnesota King, "	25	23.00	8.	18.50	80.43	19.57
Conqueror, "	25	23.25	7.	18.50	79.56	20.44
Early Mastadon, "	25	19.50	22.	15.00	77.44	22.56

The next to the last column of the above table gives the true relations between the varieties. Although the Minnesota King and Conqueror shrank the least in total weight, too much of the remaining weight was due to the extremely large cob which remained quite damp when weighed in March. Our northern corn on the contrary shrank none in total weight yet yielded a large percentage of shelled corn, which was also much dryer as the kernels of this variety were not so succulent at the time of harvesting as the kernels of the two above-mentioned varieties.

The experiment goes to show that in handling equal weights in the autumn more shelled corn will be obtained on using our Rhode Island Capped variety, and that the grain thus secured will be of better quality than either of the above tabulated western varieties. This fact may hold true only as far as cultivation of corn in Rhode Island is concerned, for those varieties probably were not so completely matured as was the native corn. Most dent varieties require a season fully as long as ours for perfect maturity.

During the season of 1895, however, a small area was planted to "Extra Early Leaming" field corn, a yellow dent variety which in the most favorable circumstances matures in 100 days from time of planting, and this season ripened perfectly.

The seed was a trial package sent out by the Seed Division of the Department of Agriculture, Washington, D. C., and about one-fifth of an acre of land which had formerly been used for a pasture and was, in 1891, planted to potatoes, with a dressing at the rate of about 10 cords of barn yard manure per acre, and followed by blackberries and raspberries without the use of manure or fertilizer again until 1895, when about 20 cords of barn yard manure were applied per acre and plowed under, and it was then planted to this seed corn. It was in a location isolated from other varieties of corn and consequently produced corn true to the variety. The corn was planted on May 11th. The hills were put in 3½ feet apart each way. The seed sprouted and came up very evenly and grew rapidly; very little cultivation was necessary, for the corn plants soon shaded the ground and retarded the growth of weeds.

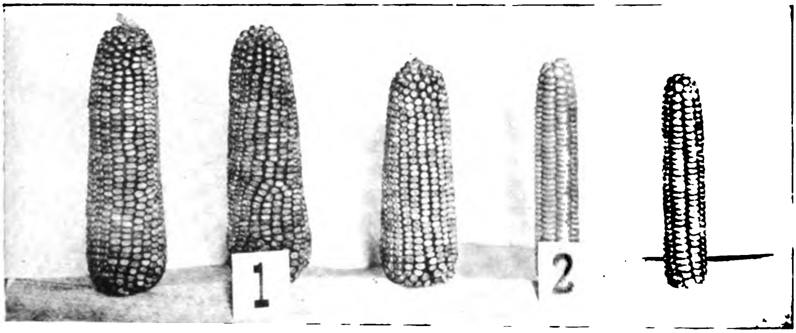
By September 15th the stalks had reached the height of 11 to 13 feet, many of which bore two ears each at a height of 4 to 6 feet from the ground. (Fig. 1.)

The crop was left standing as late as possible, in order that it might fully mature and yet not be at the mercy of the frost.

The corn was cut on September 27th and set up into shocks. It required two men to bind the shocks and they were obliged to stand on barrels in order to bind at the proper height. (Fig. 2.) On October 19th the corn was husked and the stover and ears weighed. The latter gave a yield at the rate of 115.7 bushels of shelled corn per acre, and the stover weighed at the rate of 6.3 tons per acre, while our R. I. Capped corn, although planted on not so strong land, produced 62.27 bushels of shelled corn, and 1.96 tons of stover per acre.

The Leaming variety of dent corn originated in Ohio, and is considerably grown in the western and southern states. From twenty-two experiments conducted in thirteen different states of this country, it is observed that the grain did not mature in four of them, viz.: Wisconsin, South Dakota, Vermont and Minnesota, while in Mississippi, Arkansas, Indiana, Illinois, Louisiana, Tennessee, Ohio, Kansas and Iowa, it matured very satisfactorily. The average length of season of its maturity is 118 days, with a height of stalk reaching ten feet on an average, ranging from 7 feet to 12 feet. It has been grown with over 150 other varieties, and it ranks with the best in every case, and in some cases it is found ranked among the very best, maturing early and producing large yields of grain and stalk. The length of ear varies from 7½ inches to 10 inches, and produces, averaging from the whole number of experiments, a yield of 53 bushels of shelled corn per acre, the greatest yield being about 75 bushels. The average weight of stover is found to be about 3 tons per acre, while the highest yield was but 4 tons. The average weight of green fodder is 20 tons per acre, with a maximum yield of 25 tons.

Leaming Corn.



No. 1. Leaming Corn. No. 2. R. I. Capped Corn.

Leaming Corn. (binding shocks).

It should be borne in mind that the flint varieties of corn are little grown in the above named states in which the Leaming corn matures, owing to the fact that the yield of the former does not approximate that of the dent varieties in those states. Perhaps our soil was in a richer condition and the crop thereby induced to make a greater growth than was obtained in any of the above related experiments. Rather closer planting than is usual with such varieties may also have increased the yield.

This variety of corn may be grown in this State with profitable results, especially if it is grown for the purpose of putting the stover into the silo. The expense of handling such large stalks is considerable and can only be determined by conducting an experiment which would include a large area.

TABLE SHOWING SHRINKAGE OF LEAMING CORN AND RHODE ISLAND CAPPED CORN DURING STORAGE FOR FOUR MONTHS.

		LEAMING CORN.		RHODE ISLAND CAPPED CORN.	
		Oct. 21st, 1895.	Feb. 20th, 1896.	Oct. 21st, 1895.	Feb. 20th, 1896.
Corn on cob.	Weight.....pounds..	50.00	43.25	50.00	46.25
	Shrinkage.....pounds..		6.75		3.75
	Shrinkage.....per cent.		13.50		7.50
Shelled Corn.	Weight.....pounds..	38.33	32.82	41.11	38.07
	Shrinkage.....pounds..		5.51		3.04
	Shrinkage.....per cent.		14.40		7.40
	Yield per acre.....(bushel 56 lbs).	135.16	115.70	67.24	62.27
Weight of ears per 56 lbs. shelled corn.....		73.04	73.80	68.11	68.03
Per cent. of cob.....		23.33	24.12	17.78	17.69
Per cent. of shelled corn.....		76.67	75.88	82.22	82.31
Pounds of ears in October, 1895, per 56 lbs. of shelled corn in February, 1896.....		82.10		73.50	

From the above table it is very evident that with equal weights of the two varieties stored in the autumn, the Rhode Island Capped corn will produce more shelled corn in the spring. Yet if the Leaming variety yields much more per acre, the question of which variety to use will be largely determined by the attending circumstances and conditions.

FORAGE PLANTS.

ALFALFA.

(*Medicago Sativa.*)

Numerous articles in the agricultural papers, especially those published in the West and South, setting forth the valuable qualities of alfalfa or lucerne, lead to rather frequent inquiries on the part of eastern farmers as to whether this plant cannot be successfully cultivated here. Repeated sowings of seed have been made at this Station, thus far, however, without a permanent stand.[1] The south half of plot No. 47, sown July 12th, 1894, the west half in drills seven inches apart and the east half broadcast, was clipped off before blossoming to strengthen the root growth, and presented a fairly thrifty appearance when the ground froze. In the spring of 1895 many of the plants had been "winter killed," and such as started made a slow, feeble growth, not sufficient to keep weeds in check. That portion of the plot sown broadcast was more difficult to keep free from foul growth than the drilled portion. Few plants promised to survive another winter and the crop was considered a failure. On April 25th, plot No. 16 was plowed and well fertilized with the following mixture per acre: nitrate of soda, 105 lbs.; fine ground bone, 450 lbs.; muriate of potash, 150 lbs.; tankage, 225 lbs., and slag meal, 225 lbs. The ground was thoroughly fitted by repeated harrowing, and on April 26th the seed was sown broadcast by hand and the plot bushed and rolled. Such weeds as appeared were removed by hand and the young plants made a thrifty growth early in the season. When a few inches high a mowing machine was used to clip off the tops of the plants. Later in the season the growth was very slow and far from satisfactory and this seeding promises to corroborate the failures heretofore experienced. Through some oversight the dressing of air-slacked lime designed for this plot was not applied and therefore we can only conjecture as to its probable effect. A row was sown across plots Nos. 23, 25, 27 and 29, two of which had received liberal dressings of air-slacked lime and the growth of alfalfa on the limed plots was far superior to that upon those unlimed. At present, conditions exist in our soil and perhaps in our climate which effectually preclude the profitable cultivation of alfalfa.

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[1] See Seventh Annual Report, R. I. Expt. Sta., p. 120.

COWPEAS.

(*Dolichos.*)

The great value of the cowpea as a fodder crop and for green manuring in the Southern States has led to a trial of some of the many varieties in a number of the more Northern States. The results have shown that a large amount of valuable fodder can be produced from southern grown seed when planted so far north that seed could not be matured. Considering the value of the plant we decided to secure, if possible, seed of the two earliest varieties grown, and plant them for the purpose of securing mature seeds for planting the next season, and by repeating the process, if possible, develop a variety sufficiently early to be profitable for growing in this State. Through the kindness of Director Robert H. Miller, of the Maryland Experiment Station, two quarts of each of two varieties of cowpeas, said to be the earliest peas grown, were secured. One was a black pea and the other a black-eyed, yellowish white pea. Both were sown May 23d, 1895, in drills on plot No. 40, and kept free from weeds during the season. Both varieties made a good growth of vine, blossomed and produced pods with apparently mature seeds in them. Rhode Island grown seeds of both varieties will be planted another season from which the earliest ripe seed will be saved for planting.

CRIMSON CLOVER.

(*Trifolium Incarnatum.*)

Sometimes called "Scarlet," "Italian" or "German" clover. Repeated trials of this forage plant have been made at this Station and by individuals in various parts of the State with quite different results at different times. This clover is shorter lived than either of the other clovers, seldom if ever enduring longer than one year, and often in this latitude failing to live through a single winter. It has the merit of growing rapidly during the warm season and will quickly cover any unoccupied field in moderately good tilth with a thick growth of leaves valuable for fodder or green manuring. When sown in August in favorable localities it has lived through the winter and produced a growth by the first of the following June, two and one-half feet high. In the majority of cases it will probably fail to live through the winter. For sowing in orchards as a "catch crop" for green manuring and after winter rye and early potatoes it has considerable value.

EGYPTIAN LENTIL.

Seeds of this plant were received from the Department of Agriculture, at Washington, and sown May 22d, on well prepared sandy loam land, both broadcast and in drills. The seed is brown in color and less than the size of half a small pea which it somewhat resembles in shape. When the plants were mature they were but six to eight inches in height and of slender growth, each small seed in a separate pod. It is apparently of little value compared with Canada peas as a fodder or grain crop.

FLAT PEA.

(*Lathyrus sylvestris.*)

Much has been written in foreign journals regarding the great value of the flat pea as a forage plant. Seeds of this plant were sown in drills about fifteen inches apart, early in the spring of 1894, on sandy loam soil fairly well fertilized. The seeds germinated rather slowly, but finally gave a good stand and made a moderate growth the first season. The second season some of the tops reached a height of over two feet, but the growth was not uniform over the plot. The tops, when cut, have been readily eaten by cattle. The growth has not been sufficiently vigorous to keep down the growth of sorrel and other plants.

LEGUMINOUS AND OTHER PLANTS GROWN WITHOUT AND WITH DIFFERENT QUANTITIES OF NITROGEN.

For the third season plots 17, 19 and 21 have each received equal amounts of phosphoric acid and of potash, but plot No. 17 has received no nitrogen, while plot No. 19 has received at the rate of 150 pounds, and plot No. 21 at the rate of 450 pounds, of nitrate of soda per acre. For two seasons, only leguminous plants have been grown upon these plots, with the result that the clovers were more benefited by the small application of nitrogen, and with the soja beans the smaller application gave generally more satisfactory results than the larger.[1] A few non-leguminous field crops were grown this season that the results might be compared with those from leguminous plants. These were of course planted where leguminous crops had been grown for two years, and the yield upon plot No. 17 without the application of nitrogen, would indicate that they found a moderate supply in the soil.

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[1] See R. I. Agrl. Expt. Sta. Report, 1894, p. 117.

TABLE SHOWING WEIGHTS OF SOME LEGUMINOUS AND NON-LEGUMINOUS PLANTS GROWN WITH DIFFERENT QUANTITIES OF NITROGEN.

PLOT No.	17		19		21		Excess of yield with one-third ration of nitrogen over no nitrogen.		Excess of yield with full ration of nitrogen over no nitrogen.		Average per cent. of two years of excess of yield with one-third ration over no nitrogen.	Average per cent. of two years of excess of yield with full ration nitrogen over no nitrogen.	Cost of Nitrate of Soda per acre.		
FERTILIZERS PER ACRE.													Plot 17.	Plot 19.	Plot 21.
Dissolved Phosphate Rock	1200 lbs.		1200 lbs.		1200 lbs.								$0.00	$8.37½	$11.12½
Muriate of Potash	180 lbs.		180 lbs.		180 lbs.								Per cent. of Yield compared with Plot 21.		
Nitrate of Soda	....		150 lbs.		450 lbs.										
NAME OF CROP.	1894	1895	1894	1895	1894	1895	1894	1895	1894	1895			17	19	21
NON-LEGUMINOUS.							lbs.	lbs.	lbs.	lbs.					
Field Corn, ears	......	6.80	......	10.80	......	11.65	.....	8.50	......	4.85	51.47	71.32	58.37	88.41	100.00
Field Corn, stover	......	33.05	......	62.70	......	77.35	......	29.65	......	44.30	89.71	134.05	42.73	81.06	100.00
Spring Rye	......	3.65	......	3.85	......	4.55	......	0.20	......	0.90	5.48	24.66	80.21	84.62	100.00
Oats	......	31.80	......	42.20	......	44.00	......	10.40	......	12.20	32.70	38.36	72.27	95.90	100.00
Barley	......	5.10	......	9.85	......	17.10	......	4.75	......	12.00	93.14	235.29	29.82	57.60	100.00
Field Corn, drilled	......	31.55	......	36.65	......	39.65	......	5.10	......	8.10	16.16	25.67	94.70	92.43	100.00
Japanese Millet (*Italicum*)	......	10.00	......	29.25	......	23.00	......	19.25	......	18.00	192.50	180.00	43.48	127.17	100.00
Golden Wonder Millet	......	15.05	......	12.85	......	15.00	......	0.00	......	0.00	00.00	00.00	100.33	85.66	100.00
LEGUMINOUS.															
Egyptian Lentil	......	2.90	......	5.15	......	6.95	......	2.25	......	4.05	77.59	139.66	41.72	74.10	100.00
White Lupine	......	62.00	......	80.25	......	82.25	......	18.25	......	20.25	29.44	32.66	75.42	97.57	100.00
Blue Lupine	......	59.25	......	92.25	......	94.50	......	33.00	......	35.25	55.70	59.49	62.77	97.66	100.00
Yellow Lupine	78.80	93.00	83.80	123.50	131.00	132.25	5.00	30.50	52.20	39.25	20.60	58.28	70.32	93.31	100.00

Soja Bean..................medium green..	20.00	17.05	24.60	25.25	29.40	32.95	4.60	8.20	9.40	15.90	34.55	68.29	51.74	76.68	100.00
Soja Bean..................medium black..	14.00	16.95	16.20	23.65	20.60	29.45	2.20	6.60	6.60	12.40	28.35	61.89	57.55	77.92	100.00
Soja Bean..................early white.....	19.80	10.05	21.60	14.15	22.20	17.00	1.80	4.10	2.40	6.95	19.77	31.32	59.11	88.16	100 00
Black Podded Adzuki..................	14.60	21.25	15.20	28.10	28.00	31.90	0.60	6.8	8.40	10.65	20.78	69.87	66.61	88.08	100.00
White Podded Adzuki......................	20.60	17.70	21.00	17.55	26.00	21.05	0.40	0.00	5.40	3.35	1.04	22.88	84.08	82.54	100.00
Kiyusuki Daidzu	23.20	26.45	26.80	29.20	25.80	30.70	3.60	2.75	2.60	4.25	12.79	18.80	86.18	95.08	100.00
Yamagata-cha.............................	54.10	2.85	55.70	3.80	67.50	5.90	3.20	0.95	26.80	3.05	7.28	52.41	48.80	64.40	100.00
Edamame..................................	18.80	2.55	20.60	4.05	28.40	3.15	1.80	1.50	4.60	0.00	15.46	24.86	80.79	128.52	100.00
Yellow Soy.................................	27.60	1.45	33.20	3.05	87.00	6.60	3.60	1.60	11.60	5.15	17.98	57.66	21.96	46.21	100.00
White Bean.................................	......	16.45	......	24.25	......	34.80	......	17.80	......	18.85	108.21	111.55	47.27	69.68	100.00
White Bean...............(beans in pod)..	......	8.45	......	12.85	......	17.00	......	3.90	......	8.55	46.15	10.12	49.70	72.65	100.00
Golden Wax Bean..........................	......	16.65	......	34.80	......	38.20	......	18.15	......	21.55	109.60	129.48	48.59	91.10	100.00
Golden Wax Bean..........(beans in pod)..	20.20	8.95	19.20	19.40	13.60	21.30	0.00	10.55	0.00	12.45	18.09	42.70	42.01	91.08	100.00
American Wonder Pea......................	10.60	8.50	17.00	19.45	11.40	28.25	6.40	10.95	0.80	14.75	90.84	81.41	36.59	88.65	100.00
American Wonder Pea ......(peas in pod)..	......	4.50	......	6.75	......	9.25	......	4.25	......	4.75	94.44	105.55	48.65	94.59	100.00
Melting Sugar Pea	......	15.60	......	29.20	......	35.80	......	18.60	......	20.20	87.17	129.49	48.57	81.56	100.00
Melting Sugar Pea..........(peas in pod)..	......	8.15	......	18.50	......	16.10	......	5.35	......	7.95	65.64	97.55	50.62	88.85	100.00
Sterling Pea................................	......	11.20	......	25.15	......	33.05	......	16.95	......	21.85	151.48	195.09	33.88	76.10	100.00
Sterling Pea.................(peas in pod)..	......	5.75	......	14.95	......	17.85	......	9.20	......	12.10	160.00	210.48	32.21	88.75	100.00
Unknown Cowpea	113.80	78.20	118.80	95.65	134.80	109.55	0.00	22.45	23.00	36.35	12.04	31.82	66.81	87.31	100.00
Serradella............	......	44.40	......	90.45	......	118.15	......	46.05	......	73.75	103.72	166.10	37.58	76.55	100.00

It will be noticed from the table that plot No. 17, as compared with plot No. 21, produced more than 50 per cent. as much in the case of spring rye, oats, drilled field corn, Golden Wonder millet, and also field corn when the total product is considered. In the case of the millet the yield exceeded that upon plot No. 21, which received the large amount of nitrogen. Plot No. 19 gave more than 80 per cent. of as much as plot No. 21 in every case excepting barley, which it will be noticed was especially benefited by the increased amount of nitrogen. In the case of the Japanese millet, plot No. 19 gave fully one-fourth more crop than plot No. 21, and about three times as much as plot No. 17—a decidedly marked effect from the application of a moderate quantity of nitrogen.

With regard to the leguminous plants only one—the Japanese bean called "Edamame"—gave a greater yield upon either plot 17 or 19 than upon plot 21. In this case the yield upon plot 17 without nitrogen was over 80 per cent. as great as that of plot 21, while plot 19 gave a crop over one-fourth greater than that from plot 21. Of the twenty-five weights tabulated, twelve of those upon plot 17 exceeded 50 per cent. of those from crops grown upon plot 21, while only three exceed 80 per cent. The yields from plot 19 compared with plot 21 show that sixteen of the twenty-five weights exceed 80 per cent. of those from plot 21, so that it is plainly evident that the larger amount of nitrogen was not profitably used.

In the accompanying diagrams the cost of fertilizer is represented by the heavy lines upon the *left* of the central line, 100 being taken as a basis and representing the cost of the phosphoric acid and potash without nitrogen. The crops produced are represented by the heavy lines upon the *right* of the central line, 100 representing in the case of each crop the yield upon plot 17 without nitrogen.

DIAGRAM SHOWING THE RELATIVE COST OF FERTILIZERS AND YIELDS OF CROPS ON PLOTS 17, 19 AND 21.

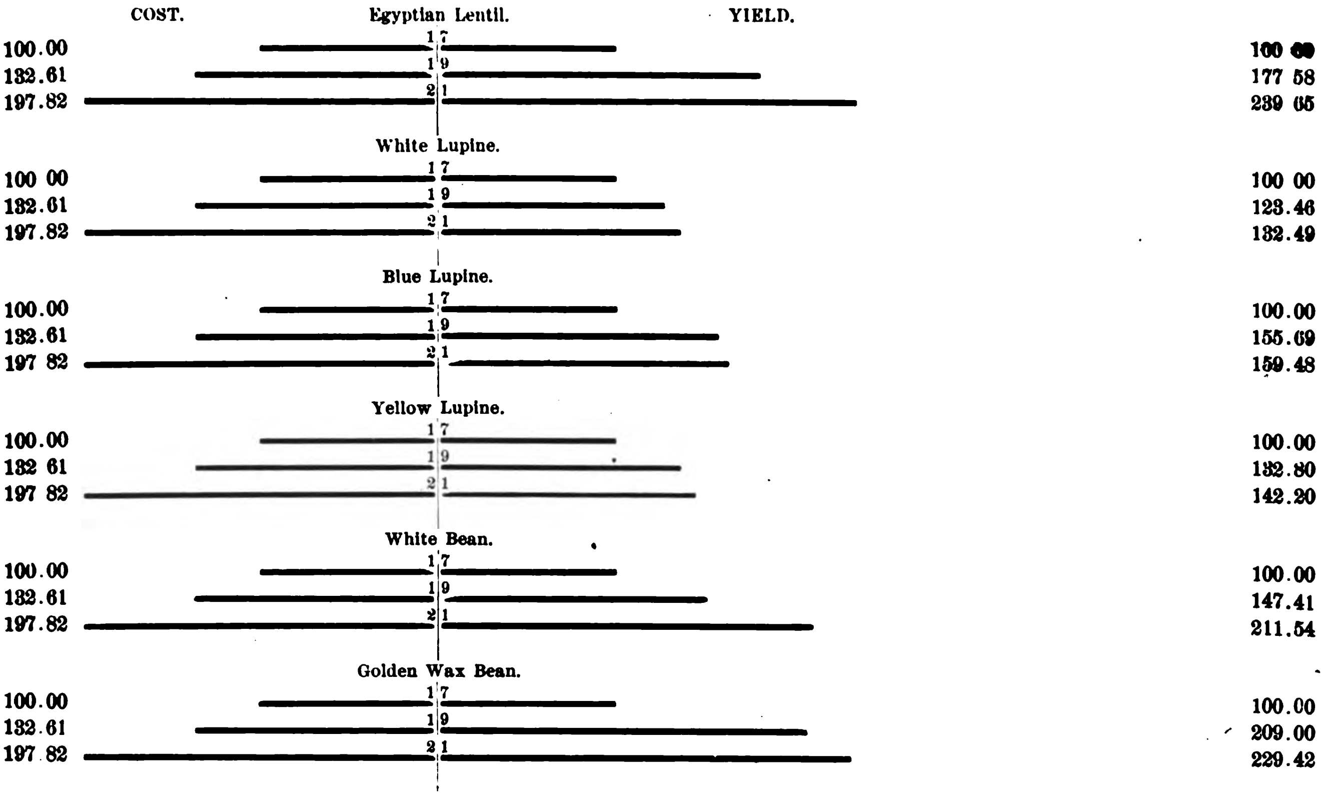
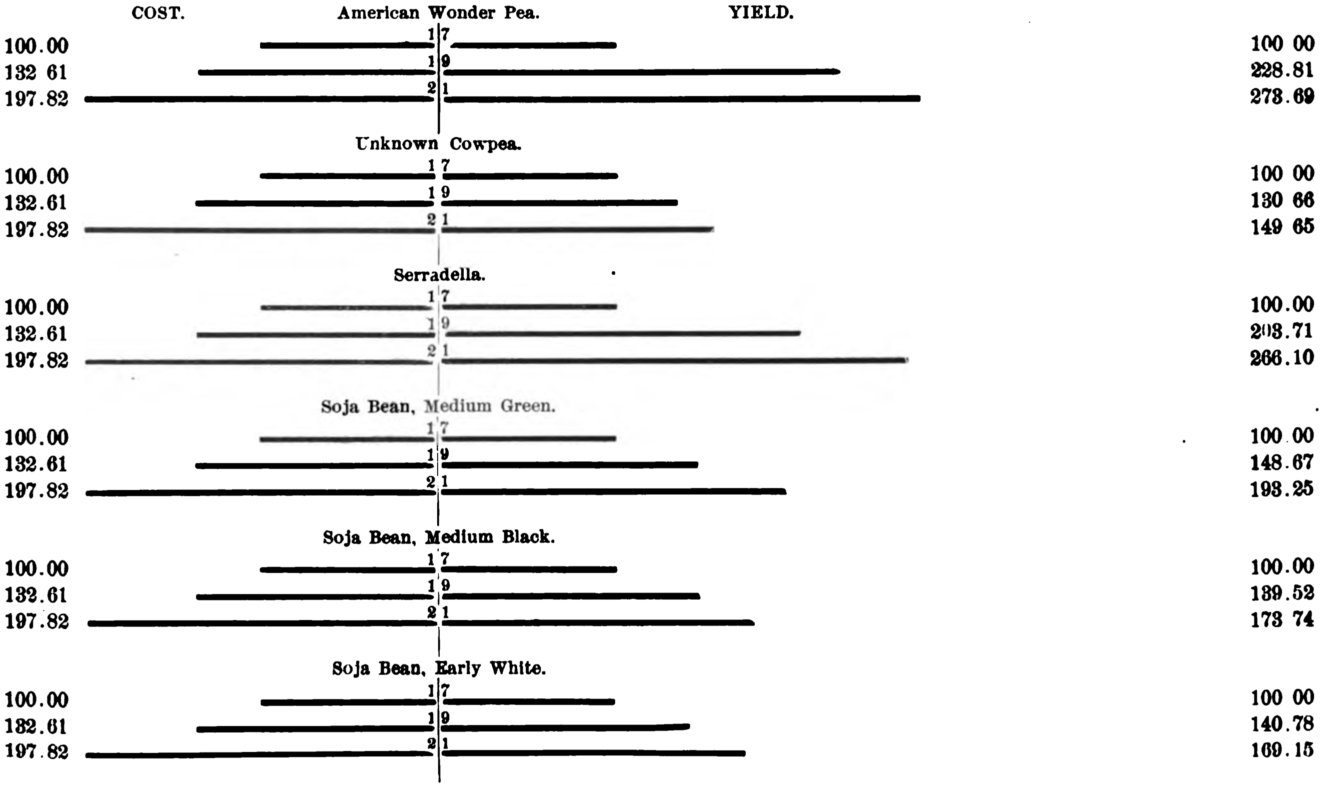


Diagram showing the Relative Cost of Fertilizers and Yields of Crops on Plots 17, 19 and 21.



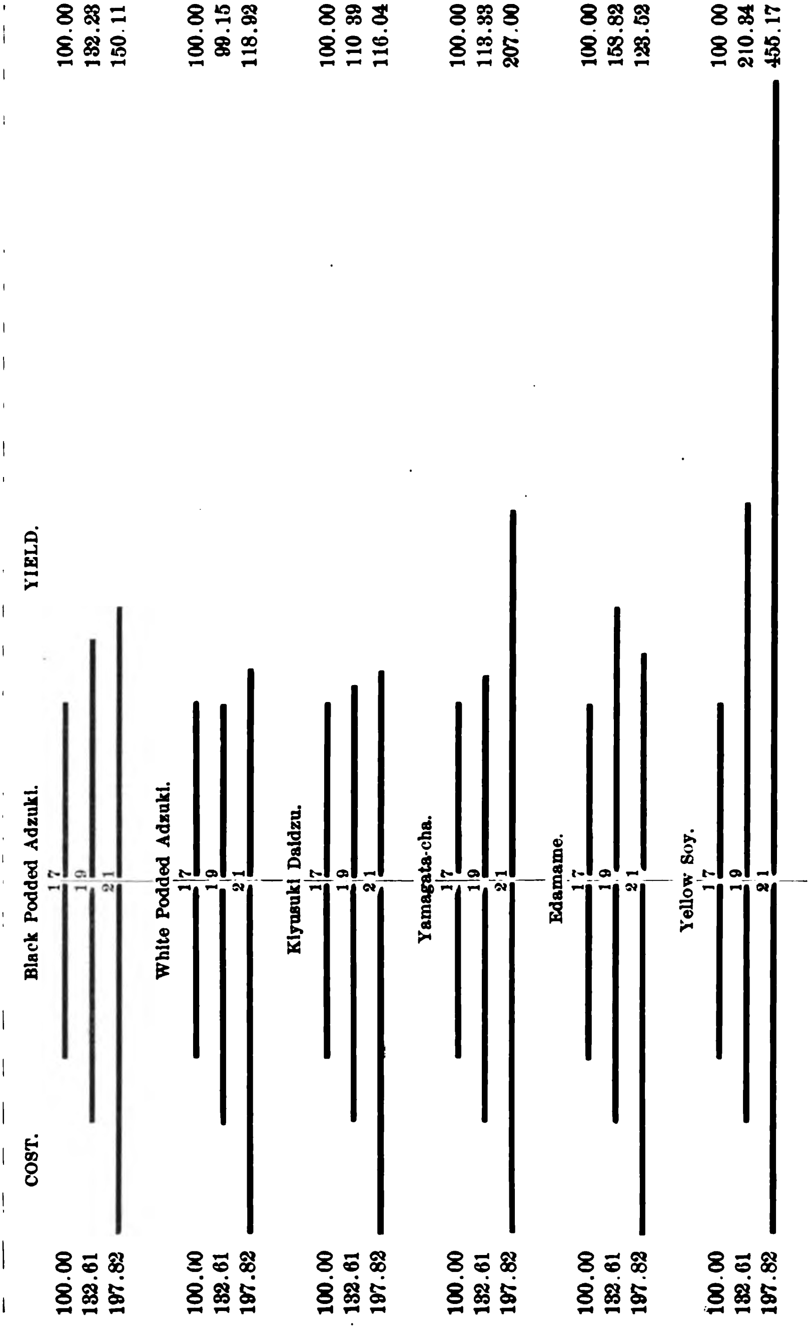
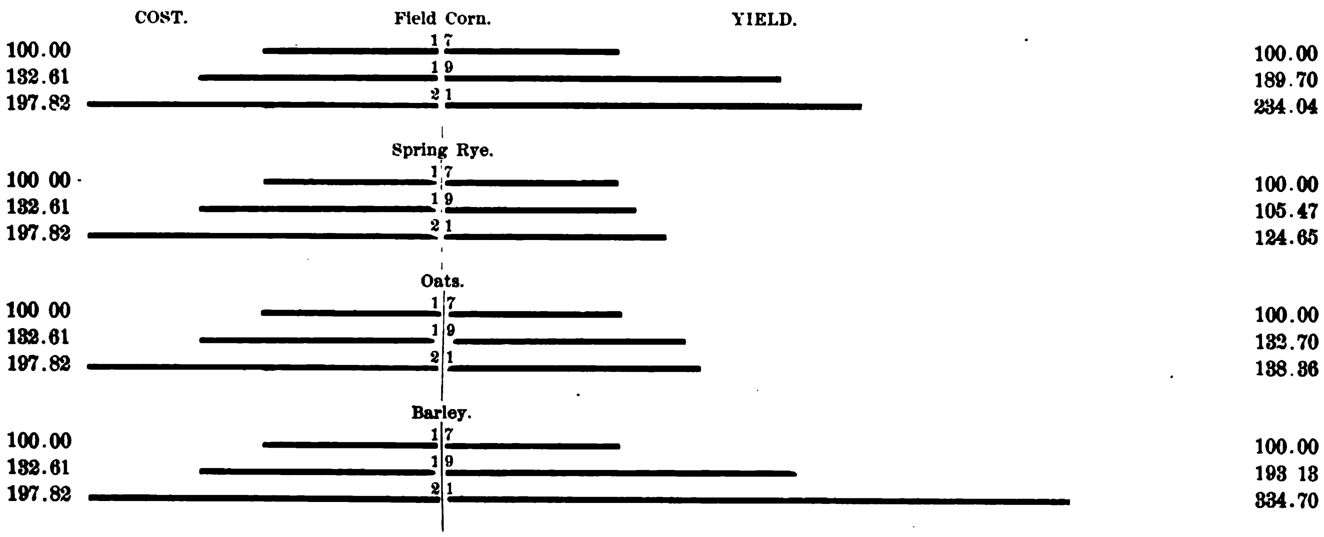


DIAGRAM SHOWING THE RELATIVE COST OF FERTILIZERS AND YIELDS OF CROPS ON PLOTS 17, 19 AND 21.

DIAGRAM SHOWING THE RELATIVE COST OF FERTILIZERS AND YIELDS OF CROPS ON PLOTS 17, 19 AND 21.



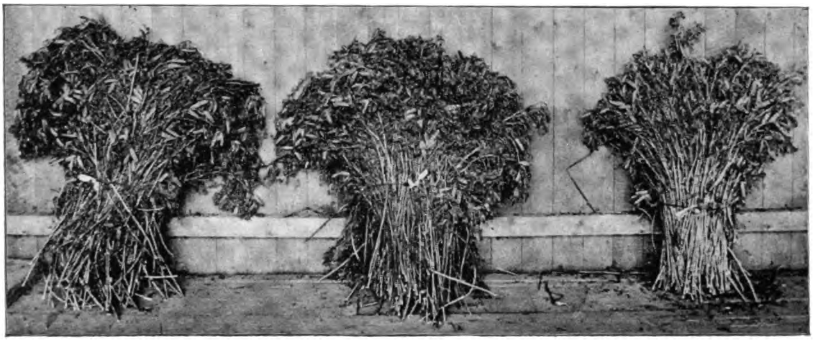


FIG. 1. WHITE LUPINE.

Plot 21.	Plot 19.	Plot 17.
Full ration nitrogen.	One-third ration nitrogen.	No nitrogen.

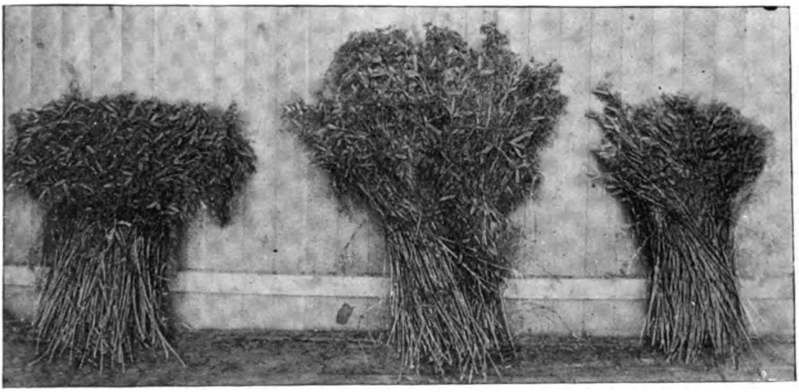


FIG. 2. BLUE LUPINE.

Plot 21.	Plot 19.	Plot 17.
Full ration nitrogen.	One-third ration nitrogen.	No nitrogen.

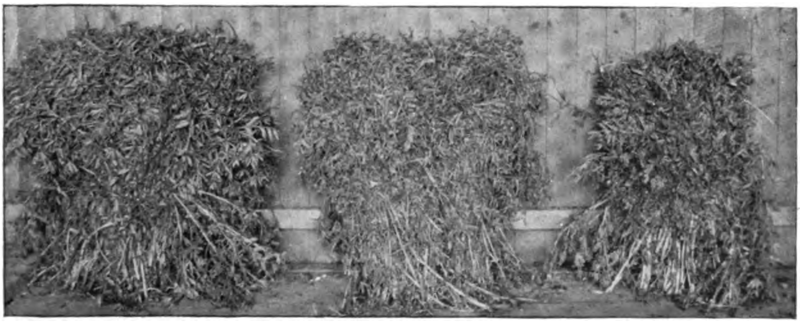


FIG. 3. YELLOW LUPINE.

Plot 21.	Plot 19.	Plot 17.
Full ration nitrogen.	One-third ration nitrogen.	No nitrogen.

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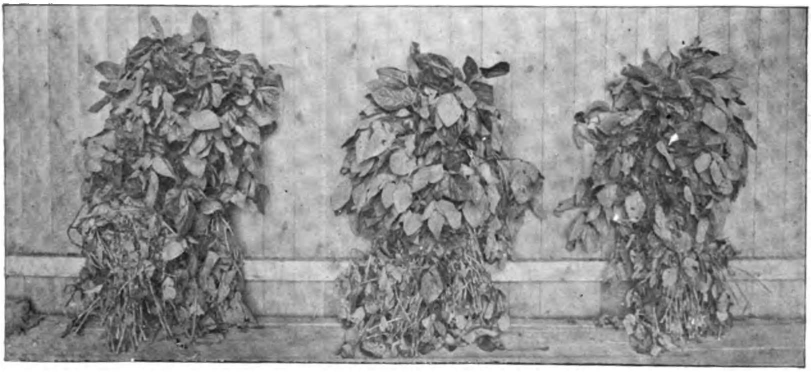

FIG. 4. MEDIUM GREEN SOJA BEAN.

Plot 21.
Full ration nitrogen.

Plot 19.
One-third ration nitrogen.

Plot 17.
No nitrogen.

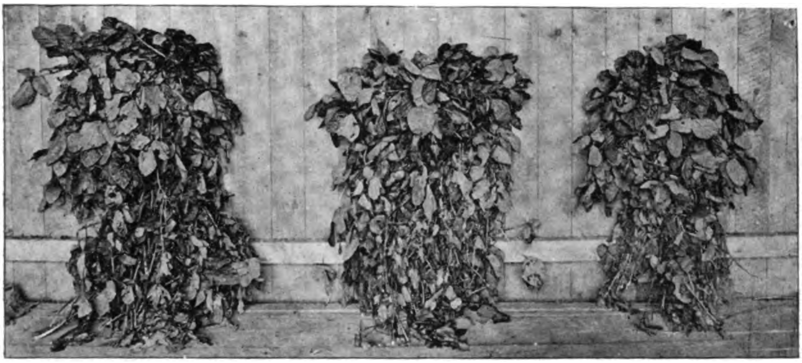

FIG. 5. MEDIUM BLACK SOJA BEAN.

Plot 21.
Full ration nitrogen.

Plot 19.
One-third ration nitrogen.

Plot 17.
No nitrogen.

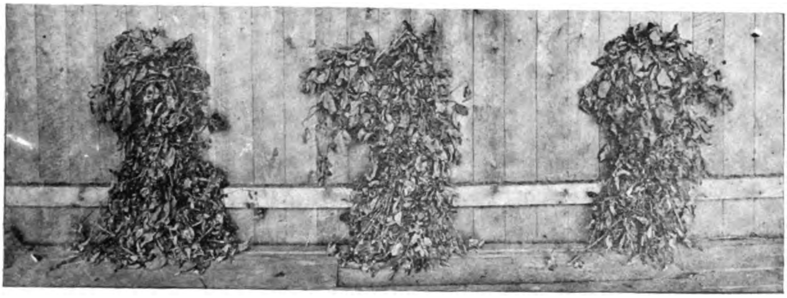

FIG. 6. EARLY WHITE SOJA BEAN.

Plot 21.
Full ration nitrogen.

Plot 19.
One-third ration nitrogen.

Plot 17.
No nitrogen.

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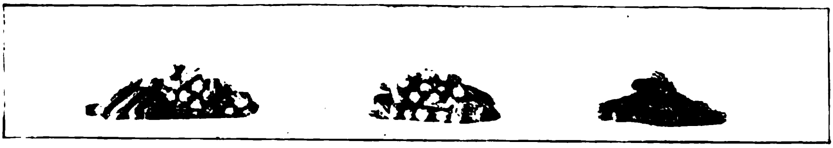

FIG. 7. R. I. CAPPED CORN.

Plot 21.	Plot 19.	Plot 17.
Full ration nitrogen.	One-third ration nitrogen.	No nitrogen.

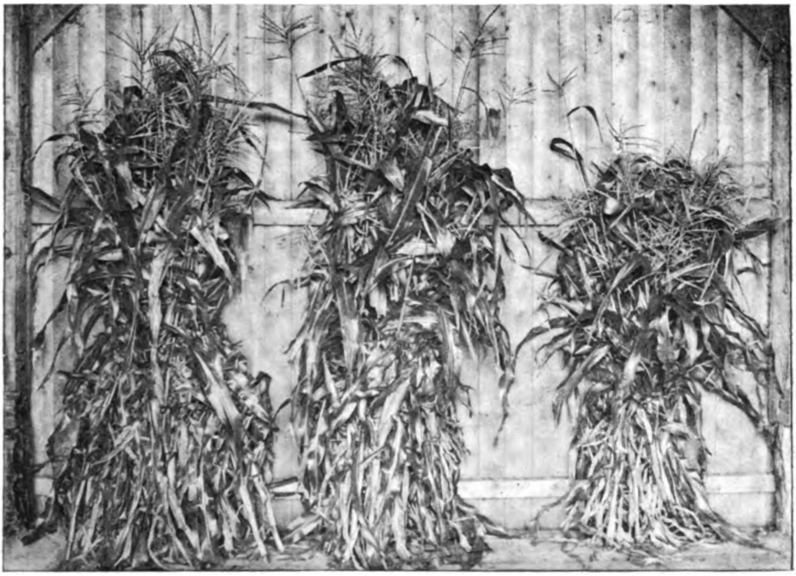

FIG. 8. FODDER CORN.

Plot 21.	Plot 19.	Plot 17.
Full ration nitrogen.	One-third ration nitrogen.	No nitrogen.

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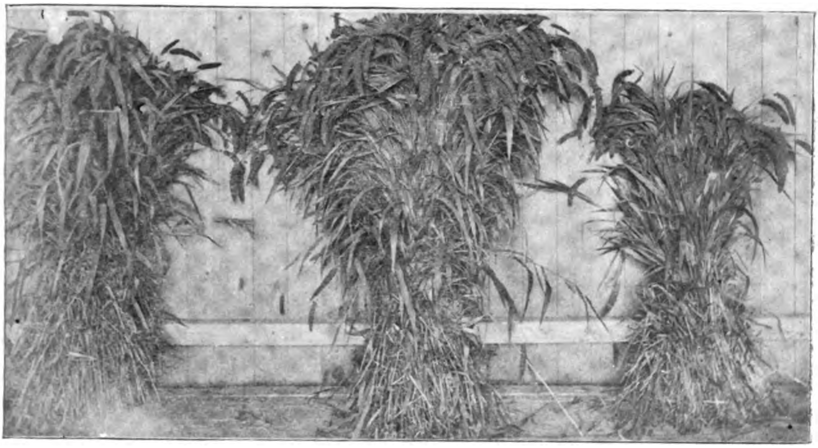


FIG. 9. JAPANESE MILLET.

Plot 21.	Plot 19.	Plot 17.
Full ration nitrogen.	One-third ration nitrogen.	No nitrogen.

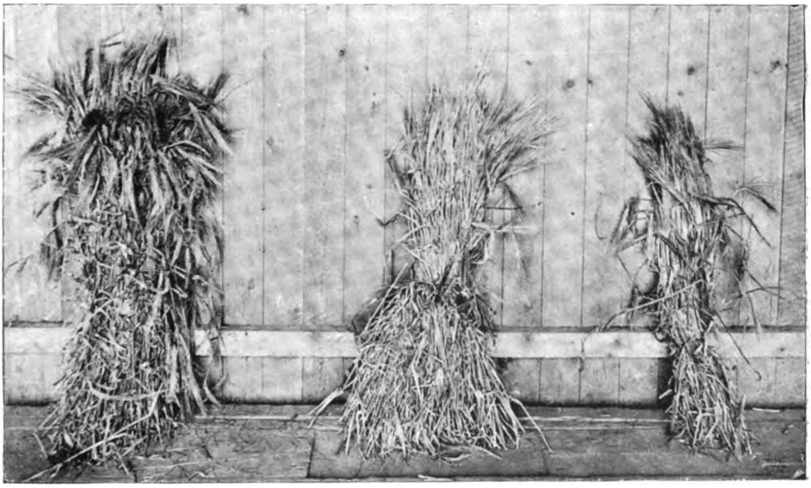


FIG. 10. BARLEY.

Plot 21.	Plot 19.	Plot 17.
Full ration nitrogen.	One-third ration nitrogen.	No nitrogen.

UNIV. OF MICH.

POULTRY DIVISION.

EXPERIMENTS WITH GEESE.

(Three Seasons.)

SAMUEL CUSHMAN.

That the geese product of the State exceeds the turkey product and stands next in value to that of hens, is not generally realized. According to the State Census for 1885, the value of the hen product was $506,454, that from geese amounted to $23,627, while the turkey crop was valued at $17,923.

Great quantities of geese have long been reared in the southern part of the State, and their fame has almost if not quite equalled that of the Rhode Island turkey in the city markets of the east. Along the shores of Narragansett Bay and the Sound, and especially about Tiverton and Little Compton, geese are more generally kept than in any other part of New England. In the region of Narragansett Pier, Point Judith, Westerly, and on Block Island, many farmers raise geese. The young geese are bought in great numbers by dealers who fatten them and prepare them for market with such success that Rhode Island geese bring more in Boston and New York than those from any other part of the country. In fact the home supply is not equal to the demand, and to prolong the season and fill their orders dealers are obliged to secure geese in Canada, Prince Edward's Island, and other sections of the country.

The details of geese raising are very little understood except by those who have long followed the business, and outside of the dealers and marketmen very little is known of this industry. In 1885, 3,261 geese were kept in Little Compton, 903 in Portsmouth, 852 on Block Island, 784 in Tiverton, 476 in South Kingstown, 333 in Middleton, 207 in Charlestown, 204 in Bristol, and 196 in Jamestown. In all 8,677 geese were enumerated, valued at $14,437. Their gross product amounted to $23,627, or 163 per cent. of their value.

That geese raising may be made profitable when rightly managed may be seen by again referring to the census figures. The Little Compton geese, 3,261, valued at $5,676, produced $13,362 worth of goslings, or 235 per cent. of their estimated value. The hens and chickens valued at $17,061, produced $33,773 worth of eggs and poultry, or 197 per cent. of their valuation. In Tiverton the number of geese kept was 784, valued at $1,553, while their estimated product was $3,907, or 251 per cent. of their valuation. The hen product of Tiverton was 203 per cent. of the valuation of the stock kept. Several expert geese raisers inform us that geese pay better than sheep, and Mr. Wm. Rankin, who has a large dairy at Brockton, Mass., has found that a good goose under his management pays as well as an average cow.

Geese are probably the hardiest of all domestic fowl, require less attention than cows or hens, and little or no outlay for buildings. The old geese do well in all weathers with nothing in the way of shelter but a shed to run under, and usually they disdain that. They do best on wet or marshy land where hens and turkeys would not thrive. They are, however, very different from other fowls, and unless their nature is understood and their requirements met they are the least profitable of all stock. The desirability of extending a knowledge of the best methods of geese raising throughout the State, as well as making experiments that will throw more light on this subject, is evident from the facts above stated.

Upon the establishment of this Division, the Board of Managers, realizing the importance of geese raising, decided that something should be done for this as well as other branches of the poultry industry, and the head of this Division was instructed to import from Germany a few Embden or Bremen geese for breeding purposes. In the fall of 1891 a pair and a trio of young geese were procured from different parties in Germany, and in 1892 a number of young birds were reared.

To learn something as to which was the most profitable to raise for market, pure Embden, pure Toulouse, or crosses between the two breeds of geese, preparations for an experiment were made early in 1893.

FIRST SEASON'S EXPERIMENT.

1893.

Some fine Toulouse geese were procured. A young Embden gander was mated to Toulouse geese, and a two year old Toulouse gander to young Embden geese, which were bred from as well as the old pair and trio of pure Embdens. Eggs and just hatched goslings of the pure Toulouse breed were also procured for comparison. The Toulouse geese were obtained late in the winter, and each of the four lots was confined to an ordinary hen yard and was doubtless fed more grain than was desirable. Few eggs were secured, and early in the season the proportion of fertile eggs was not large. These eggs were kept until a number from each yard had been secured, then set at one time, and the goslings marked as soon as hatched by punching holes in the webs of their feet to distinguish each kind. They were fed and cared for alike except that some lots were brooded by geese and others by Cochin hens. They were weighed every week to compare their growth. The following is a record of their weights:

TABLE GIVING THE WEIGHTS OF DIFFERENT KINDS OF GOSLINGS, OF THREE SEPARATE HATCHES, AT VARIOUS DATES.

	JUNE 19, 1893.			JUNE 26, 1893.				JULY 3, 1893.			
HATCHED MAY 14, 1893.	No. of Goslings.	Total.	Average.	No. of Goslings.	Total.	Average.	Gain.	No. of Goslings.	Total.	Average.	Gain.
Pure Embden	3	13.56	4.52	3	18.13	6.04	1.52	3	22.44	7.48	1.44
Embden Toulouse	4	16.56	4.14	4	22.19	5.55	1.41	4	27.13	6.78	1.23
Toulouse Embden	4	18.50	4.63	4	24.44	6.11	1.48	4	27.44	6.86	.75
Pure Toulouse	3	11.19	3.73	2	8.31	4.16	.43	2	10.94	5.47	1.31
Pure Toulouse	15	47.63	3.18	15	65.94	4.40	1.22	15	82.19	5.48	1.08
HATCHED MAY 28, 1893.	JUNE 19.			JUNE 26.				JULY 3.			
Embden	2	1.81	.91	2	2.81	1.41	.50	2	5.00	2.50	1.09
Pure Toulouse	4	5.75	1.44	4	9.06	2.27	.83	4	14.19	3.55	1.28
Toulouse Embden	4	4.38	1.10	3	5.94	1.98	.88	3	10.31	3.44	1.46
Cross-bred (unmarked)	3	3.81	1.27	3	7.25	2.42	1.15	3	11.75	3.92	1.50
HATCHED JUNE 22, 1893.				JUNE 26.				JULY 3.			
Embden Toulouse	..	..	..	5	1.50	.30	..	4	1.44	.36	.06
Embden Toulouse	..	..	..	12	3.75	.31	..	12	6.69	.56	.25
Toulouse Embden	..	..	..	7	1.94	.28	..	5	2.13	.43	.15
Pure Embden	..	..	..	2	.50	.25	..	2	.69	.35	.10

TABLE GIVING THE WEIGHTS OF DIFFERENT KINDS OF GOSLINGS, ETC.—Continued.

HATCHED MAY 14, 1893.	JULY 10, 1893.				JULY 17, 1893.				JULY 24, 1893.			
	No. of Goslings.	Total.	Average.	Gain.	No. of Goslings.	Total.	Average.	Gain.	No. of Goslings.	Total.	Average.	Gain.
Pure Embden	3	23.63	7.88	.40	3	25.88	8.63	.75	3	26.81	8.94	.31
Embden Toulouse	4	29.63	7.41	.63	4	33.44	8.36	.95	4	34.38	8.60	.24
Toulouse Embden	4	29.31	7.33	.47	4	32.81	8.20	.87	4	31.63	7.91	loss .29
Pure Toulouse	2	12.38	6.19	.72	2	14.06	7.03	.94	2	14.75	7.38	.35
Pure Toulouse	15	98.56	6.57	1.09	15	108.06	7.21	.64	15	114.31	7.62	.41
HATCHED MAY 28, 1893.	JULY 10.				JULY 17.				JULY 24.			
Embden	2	7.06	3.53	1.07	2	7.38	3.69	.16	2	9.50	4.75	1.06
Pure Toulouse	4	19 56	4.89	1.34	4	20.44	5.11	.22	4	25.38	6.35	1.24
Toulouse Embden	3	14.19	4.73	1.29	3	15.19	5.06	.33	3	18.63	6.21	1.15
Cross-bred (unmarked)	3	16.38	5.46	1.54	3	17.38	5.79	.33	3	21.81	7.27	1.48
HATCHED JUNE 22, 1893.	JULY 10.				JULY 17.				JULY 24.			
Embden Toulouse	2	1.63	.82	.46	2	3.25	1.63	.81	2	5.25	2.63	1.00
Embden Toulouse	12	11.88	.91	.35	12	19.00	1.58	.67	12	31.50	2.63	1.05
Toulouse Embden	5	3.88	.78	.35	5	6.25	1.25	.47	3	7.75	2.58	1.33
Pure Embden	1	.63	.63	.28	1	1.00	1.00	.47	1	1.88	1.88	.88

TABLE GIVING THE WEIGHTS OF DIFFERENT KINDS OF GOSLINGS, ETC.—Continued.

HATCHED MAY 14, 1893.	JULY 31, 1893.				AUGUST 7, 1893.				AUGUST 14, 1893.			
	No. of Goslings.	Total.	Average.	Gain.	No. of Goslings.	Total.	Average.	Gain.	No. of Goslings.	Total.	Average.	Gain.
Pure Embden	3	27.50	9.17	.23	3	28.56	9.52	.35	3	29.50	9.83	.31
Embden Toulouse	4	36.50	9.13	.53	4	37.81	9.45	.32	4	39.69	9.92	.47
Toluouse Embden	4	32.00	8.00	.06	4	32.44	8.11	.11	4	35.19	8.80	.69
Pure Toulouse	2	15.31	7.66	.28	2	15.94	7.97	.31	2	16.19	8.10	.13
Pure Toulouse	15	117.44	7.83	.21	15	122.00	8.13	.30	13	111.31	8.56	.43
HATCHED MAY 28, 1893.	JULY 31.				AUGUST 7.				AUGUST 14.			
Embden	2	11.38	5.69	.94	2	12.56	6.28	.59	2	14.25	7.13	.85
Pure Toulouse	4	27.19	6.80	.45	4	29.00	7.25	.45	4	32.88	8.22	.97
Toulouse Embden	3	20.00	6.67	.46	3	20.56	6.85	.18	3	22.69	7.56	.71
Cross-bred, (unmarked)	3	23.63	7.88	.61	3	25.81	8.60	.72	3	29.00	9.67	1.07
HATCHED JUNE 22, 1893.	JULY 31.				AUGTST 7.				AUGUST 14.			
Embden Toulouse	2	8.75	4.38	1.75	14	73.19	5.23	2.16	14	93.75	6.70	1.47
Embden Toulouse	12	36.88	3.07	.44								
Toulouse Embden	3	12.75	4.25	1.67	3	15.00	5.00	.75	3	18.44	6.15	1.15
Pure Embden	1	2.88	2.88	1.00	1	3.75	3.75	.87	1	5.31	5.31	1.56

TABLE GIVING THE WEIGHTS OF DIFFERENT KINDS OF GOSLINGS, ETC.—Continued.

HATCHED MAY 14, 1898.	AUGUST 21, 1898.				AUGUST 28, 1898.				SEPTEMBER 5, 1898.			
	No. of Goslings.	Total.	Average.	Gain.	No. of Goslings.	Total.	Average.	Gain.	No. of Goslings.	Total.	Average.	Gain.
Pure Embden	3	32.00	10.67	.84	3	33.06	11.02	.35	3	36.50	12.17	1.15
Embden Toulouse	4	42.00	10.50	.58	4	41.69	10.42	loss .08	4	47.13	11.78	1.36
Toulouse Embden	4	36.00	9.00	.20	4	35.81	8.95	loss .05	4	40.44	10.11	1.16
Pure Toulouse	2	18.00	9.00	.90	2	17.81	8.91	loss .09	2	20.81	10.41	1.50
Pure Toulouse	13	127.50	9.81	1.25	13	126.06	9.70	loss .11	13	138.69	10.67	.97
HATCHED MAY 28, 1898.	AUGUST 21.				AUGUST 28.				SEPTEMBER 5.			
Embden	2	15.00	7.50	.37	2	15.88	7.94	.44	2	18.50	9.25	1.31
Pure Toulouse	4	35.50	8.88	.66	4	36.94	9.24	.36	4	43.38	10.85	1.61
Toulouse Embden	3	24.00	8.00	.44	3	24.00	8.00	.00	3	27.31	9.10	1.10
Cross-bred (unmarked)	3	30.50	10.17	.50	3	31.00	10.33	.16	3	36.00	12.00	1.67
HATCHED JUNE 22, 1898.	AUGUST 21.				AUGUST 28.				SEPTEMBER 5.			
Embden Toulouse Embden Toulouse	14	112.38	8.03	1.33	13	114.94	8.84	.81	13	131.75	10.13	1.29
Toulouse Embden	3	23.38	7.79	1.64	3	25.75	8.58	.79	3	27.50	9.17	.59
Pure Embden	1	6.13	6.13	.82	1	6.81	6.81	.68	1	7.50	7.50	.69

In the lot hatched May 14th, the Toulouse-Embden cross led in weight at the first and second weighings, were lightest at third weighing, and stood third or fourth the remainder of the season. The pure Embden goslings gained the most from the first weighing, June 19th, to July 10th, and stood at the head after July 3d, and for the remainder of the season except on August 14th, when the Embden-Toulouse cross outweighed them. The Embden-Toulouse cross stood second during the season, except on August 14th, when they were ahead of the pure Embdens slightly and stood first. Both lots of pure Toulouse goslings of this hatch weighed the least up to August 7th, when one lot stood ahead of the Toulouse-Embden cross, or third on the list. This lot lost this place August 14th but gained it again August 21st and held it the remainder of the season. Of those hatched May 28th, the pure Toulouse goslings led at 21 days, but were distanced by an unmarked cross-bred the remainder of the season. The Toulouse-Embden cross at first weighing was third on the list, dropped to fourth on July 10th, and held this relative position until August 21st, when they were third on the list. On August 28th they had dropped to fourth position and were at the foot, or the lightest of all on September 8th. Of this hatch the pure Embdens (two birds) weighed the least until September, when they were next to the lightest, or fourth on the list. The unmarked cross, probably Embden-Toulouse, led in weight after the first weighing and was the heaviest of all the remainder of the season. Of those hatched June 22d the Embden-Toulouse, two lots, led at the start and throughout the season except one lot on July 3d. The Toulouse-Embden cross held second place while the pure Embden weighed less than either of the crosses. There were no pure Toulouse in this lot. The Embdens did best in the first lot hatched and poorest in the second and third lots. The Embden-Toulouse combination stood second best in weight in first lot hatched, and best in the second and third lots. The Toulouse-Embden cross of the first lot did better early in the season than the pure Toulouse but were at the foot on September 8th. Those in the second lot were next to the poorest throughout the season and the lightest on September 8th. Those in the third lot did better than the pure Embdens and there were no pure Toulouse goslings in this lot with which to compare them.

A majority of the goslings from the Embden-Toulouse cross were white, or nearly white, in plumage. A few were gray, or mottled, with slate color, but all resembled Embdens. Those from Toulouse-Embden matings were darker and more like the Toulouse.

Had old stock been used in each mating the results might have been somewhat different. Young ganders are not so objectionable as young geese but their goslings would not be as strong. Old geese lay larger eggs than young geese, and their goslings would naturally be larger.

Goslings from geese like Embdens, which lay few eggs, are more apt to be strong than those from greater layers, and for this reason there would be less difference between those from young Embdens and old Toulouse geese than would be expected. Eggs that have been kept some time before incubation would not produce as strong goslings as would be secured from fresh laid eggs.

The different kinds of goslings were allowed to run together after they were weaned, and the Toulouse, in striving to keep up with the others, probably did not gain as fast as if they had been by themselves. The larger kinds, after having gained the advantage, would have the best chance. A preponderance of one sex in some lots, as well as there being a larger number of some kinds than others, would also affect the average weight.

The frequent weighings were a hindrance to their growth and probably some kinds were more susceptible to the ill effects than others. Complications that might result from the foregoing should be considered when drawing conclusions from the figures given.

The results were somewhat contradictory as regards the pure Embdens, but seemed to show that they grew faster early in the summer than the pure Toulouse. The latter attain a greater weight late in the fall and lay a greater number of eggs than

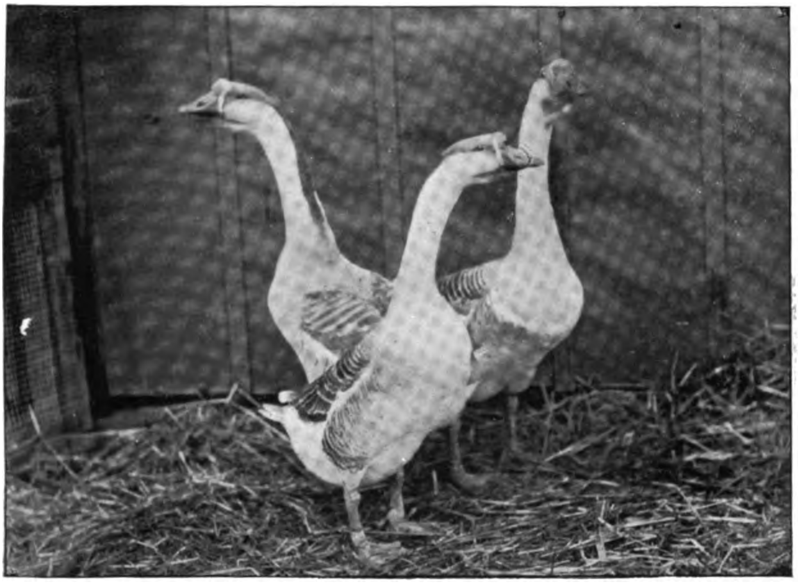
Embdens, but they are poor mothers. Embden ganders are more reliable as breeders than Toulouse ganders and when mated with Toulouse geese produce goslings, the majority of which are practically white, and resemble Embdens but grow larger. Therefore, for market production, the Embden-Toulouse cross would give more desirable results than the opposite, and would be more profitable than the pure Embden geese, if the eggs are to be hatched and the goslings reared by common hens or artificial means. The earlier hatched goslings did not grow as fast or become as plump as those hatched later.

The young geese were exhibited, accompanied by explanatory placards, at the Kingston and State Fairs, and at the winter show of the Rhode Island Poultry Association. At the latter show dressed specimens were also exhibited, and the following table shows their relative weights, both before and after they were dressed, as well as the color of plumage and shrinkage:

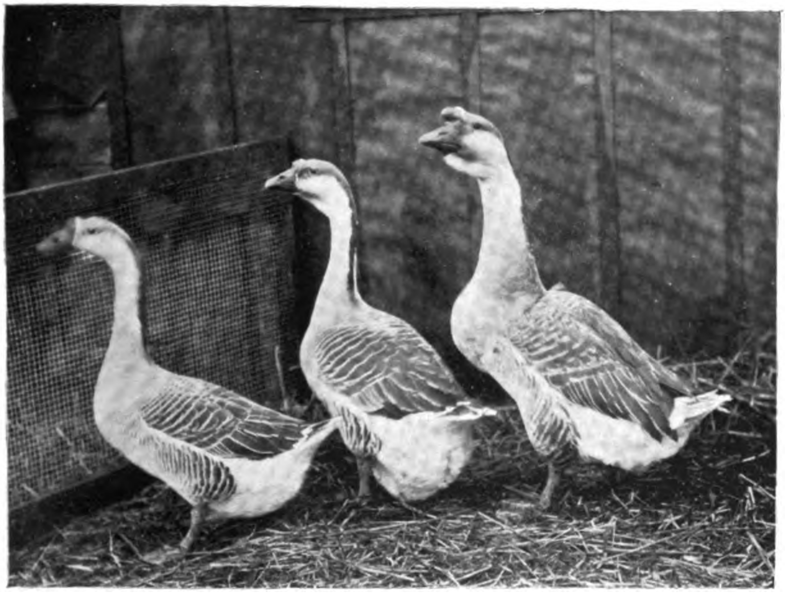
WEIGHTS OF YOUNG GEESE EXHIBITED AT WINTER SHOW OF RHODE ISLAND POULTRY ASSOCIATION, DECEMBER 12TH TO 15TH, 1893.

PARENTAGE.		Color of Plumage.	Live Weight.	Dressed Weight.	Shrinkage.	Per cent. of Shrinkage.
Male.	Female.					
Toulouse...	Embden...	Dark gray....	15.31	14.06	1.25	8.16
Toulouse...	Embden...	White........	14.50	13.00	1.50	10.37
Toulouse...	Embden...	Gray..........	13.19	12.00	1.19	9.02
Toulouse...	Toulouse..	Dark gray....	14.69	13.50	1.19	8.10
Toulouse...	Toulouse..	Dark gray....	14.63	13.50	1.13	7.70
Embden....	Toulouse..	White........	14.56	13.56	1.00	6.86
Embden....	Toulouse..	Light gray....	13.63	12.19	1.44	10.50
Embden....	Toulouse..	Gray..........	13.00	11.81	1.19	9.15
Embden....	Toulouse..	Light gray....	13.00	11.81	1.19	9.15
Embden....	Toulouse..	White........	12.25	11.19	1.06	8.65
Embden....	Embden....	White........	13.06	11.88	1.18	9.03
Embden....	Embden....	White........	8.31	7.56	.75	9.02

The latter is of little value as it would depend much upon how



PURE BROWN CHINA GEESE (YOUNG).



AFRICAN GEESE (ADULTS).

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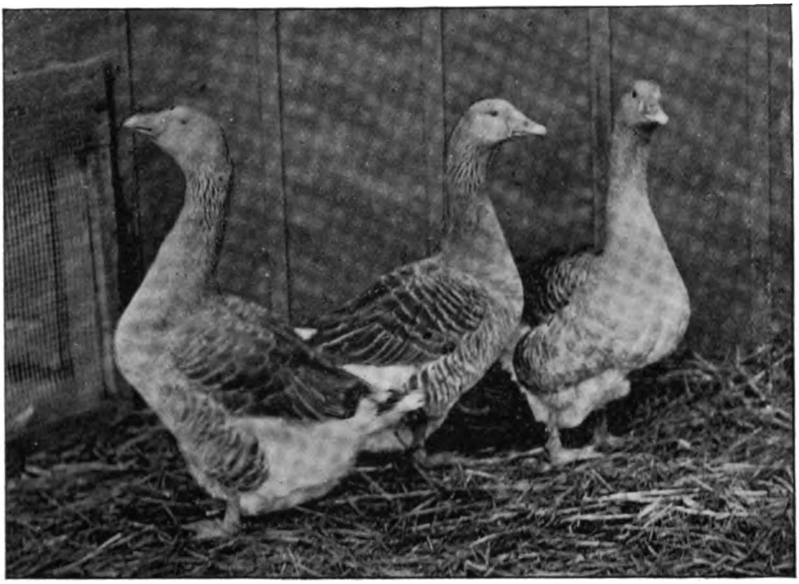
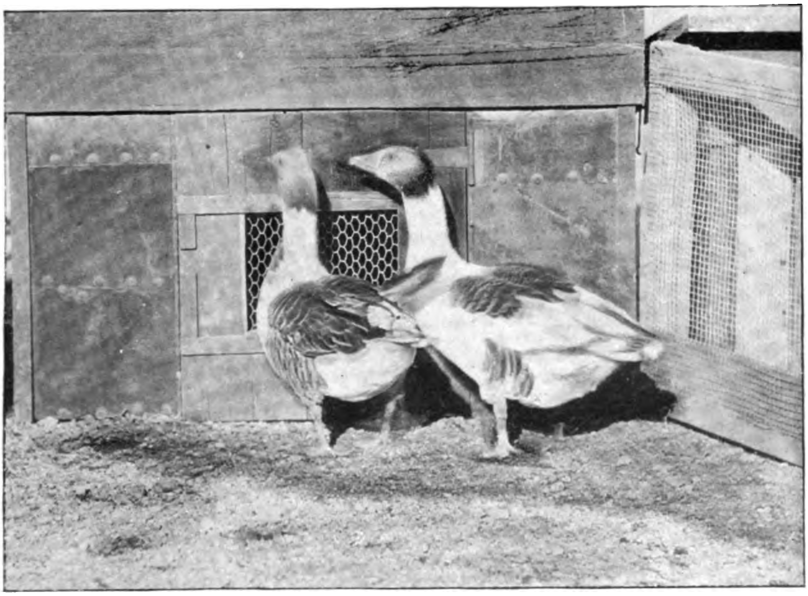


Pure Toulouse Geese (young).



Prince Edward's Island Geese (young).

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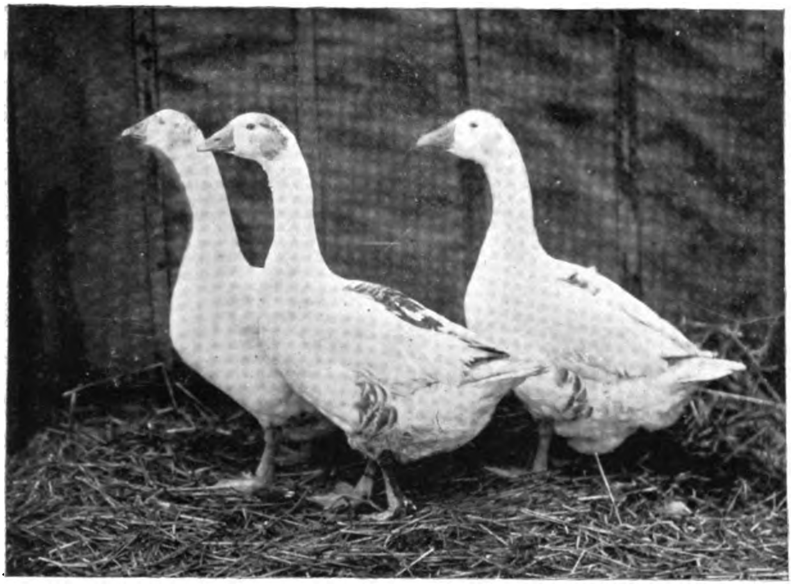
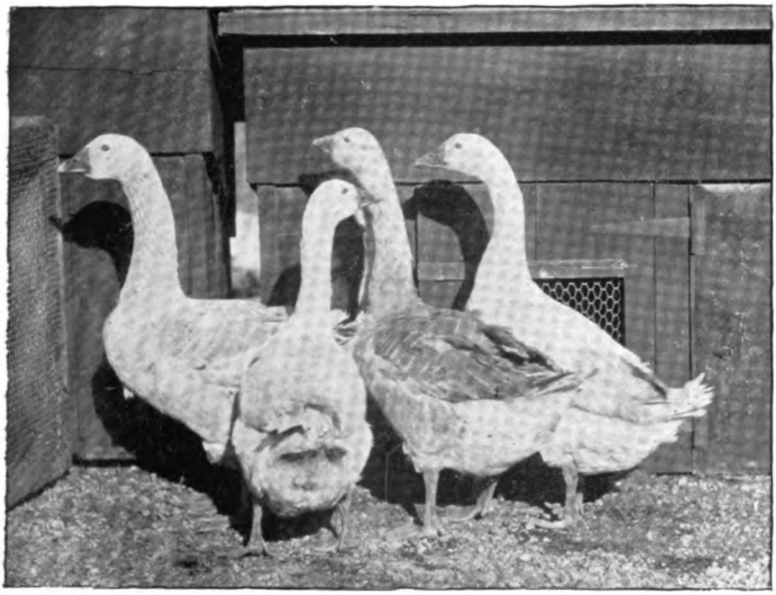


Embden and African Cross (young).



Embden and Toulouse Cross (young).

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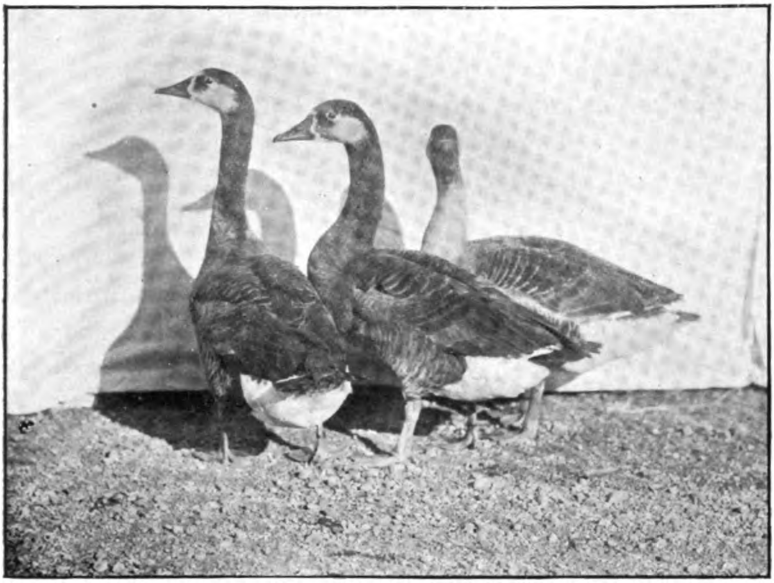
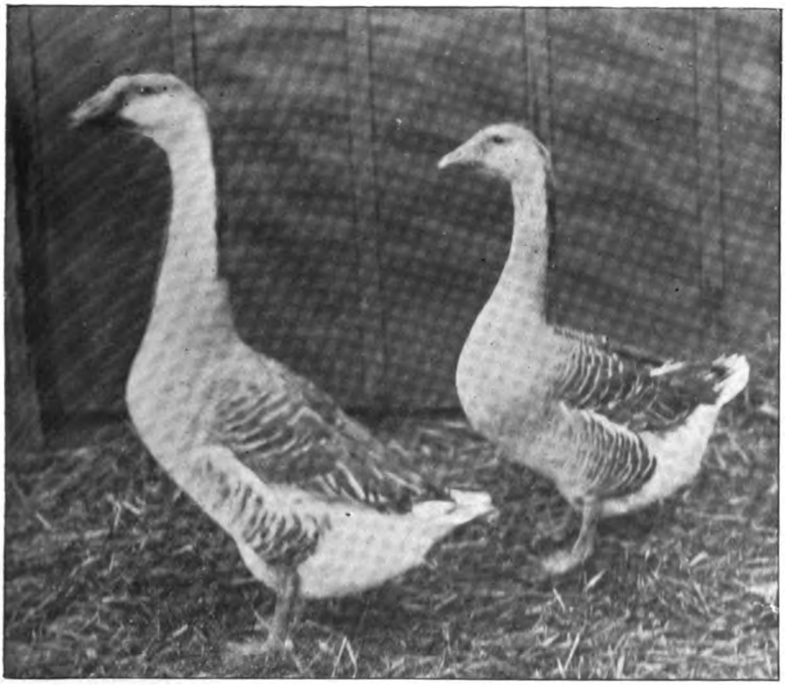


Mongrel. Wild and African Cross (young).



African and Toulouse Cross (young).

UNIV. OF MICH.

thoroughly the geese were bled. They were plucked but not drawn. As part were exhibited alive and others shown dressed, these figures cannot properly be added to the other table, but the difference in weight between those exhibited and those dressed could not have been great.

At the date of weighing, December 11th, the Toulouse-Embden cross were the heaviest, the pure Toulouse slightly heavier than the Embden-Toulouse cross, and the pure Embden weighed the least of all. This shows that the Toulouse grows larger and heavier by Christmas than the Embden, and also indicates that a Toulouse-Embden cross will weigh more than a pure Toulouse or an Embden-Toulouse cross at Christmas. The difference in weight between the two crosses was not great at this time, however, and as a larger number of the Embden-Toulouse would be secured from the same number of birds than from the opposite mating, and as the Embden-Toulouse cross made much the finer dressed gosling in appearance, both as to color and plumpness, the advantages were again on the side of the Embden-Toulouse cross.

The foregoing experiment was made secondary to several more important and extensive experiments, but the results were sufficiently satisfactory to make desirable a repetition of the work with more mature breeding geese, as well as a comparison of the other breeds and crosses that might be used in the production of goslings for market, therefore another experiment that would go into the subject still farther was planned for the following season.

SECOND SEASON'S EXPERIMENT.

1894.

While looking for fine specimens of Toulouse geese early in 1893 we learned that certain extensive and progressive geese raisers preferred African geese to the Embden or Toulouse varieties. They claimed that they were more profitable, that they laid a larger number of eggs, and that their goslings grew faster.

Desiring to compare the African variety and their crosses with

Toulouse and Embden geese and their crosses, two trios of old African geese were procured for the second season's experiment. We also bought three pairs of Prince Edward's Island geese, which, although small in size, had the reputation of being very solid, fine and plump when dressed, and might be just the stock for the production of late goslings. In buying these birds we made the mistake usually made by beginners; we waited too late in the season before attempting to procure them. We endeavored to buy them in January and February, but as good stock was hard to find and very scarce, and as owners were unwilling to sell reliable birds at this time of the year at any price, it was almost time for the geese to lay before we succeeded in obtaining the additional stock.

Some of this stock was already mated and had to be broken up and mated again. The ganders could not be removed entirely away from the sound of their former mates and thus it was more difficult to re-mate them, but Africans adapt themselves to new mates more readily than Embden or Toulouse geese. Our yards were made up as follows:

YARD NO. 3.	2 Embden Ganders.	2 Embden Geese.
YARD NO. 4.	1 Embden Gander.	1 Embden Goose.
YARD NO. 5.	1 Toulouse Gander.	2 Embden Geese.
YARD NO. 7.	1 Prince Edward's Island Young Gander.	1 Prince Edward's Island Young Goose.
YARD NO. 8.	1 Black African Gander.	1 Prince Edward's Island Young Goose.
YARD NO. 9.	1 Black African Gander.	2 Black African Geese.
YARD NO. 12.	1 Embden Gander.	2 Black African Geese.
YARD NO. 15.	1 Embden Gander.	3 Toulouse Geese.
YARD NO. 16.	1 Prince Edward's Island Young Gander.	1 Prince Edward's Island Young Goose.

The pens in which they were confined varied in size, but most of them, although large enough for a flock of fifteen or twenty hens, were too small for geese. Yard No. 15 was an exception, being about 150 x 230 feet, and within this enclosure was a low, boggy piece of ground which was partly covered with standing water during the breeding season. Some of the smaller yards had water running through them a part of the time in the spring. The trio of Africans in yard No. 9 did not have access to any water except a pailful daily during the breeding season, but their yard was covered with grass. Their journey and change of quarters evidently disturbed them very much, and few fertile eggs were secured from them.

The Embden-Toulouse mating in pen No. 15 had run together all winter and were properly mated as early as December. The geese were probably fed too much grain and did not get enough exercise, and became too fat and sluggish to give the best results. Experienced geese raisers, however, found the season unfavorable to the production of fertile eggs. The eggs were produced so irregularly by the geese in the various pens that those from some had to be kept for a long time before enough of each were received for a comparison of the results of the hatch. The eggs were marked when they were taken from the nest with the number of the yard in which they were laid. As the geese were used as setters fewer eggs were procured than if they had been broken up and encouraged to lay as long as possible. Eggs were also set under hens. As we had no yard room for other breeding geese, and extensive experiments with fowls and turkeys were then receiving our best attention, we procured eggs or goslings from Pure Toulouse, Pure Brown China, and from an Embden-African, a Wild-African, and an African-Toulouse cross mating. The goslings were raised and compared with those produced here. Some goslings were lost by being trampled upon in the nest soon after they were hatched. But one kind of eggs was left in a nest before they were to hatch, and when the goslings were removed from the nest, holes were punched in the webs of their feet to distinguish the kind or cross. They were brooded by hens or geese and confined while young to small movable pens which were changed to fresh grass frequently. They were fed every few hours during the first few days with bread crumbs moistened with milk and hard boiled eggs or scalded corn meal dough. Later they were given cracked corn as well as moistened bread and dough. The goslings brooded by hens seemed to grow faster and thrive better than those brooded by geese. They would have done better had they been given less egg and bread and more and better grass pasturage. A number were lost. They were given free range in the latter part of the summer. When at about saleable age to dealers and fatteners, they were weighed each fortnight for a time and again on December 8th. The record of the geese hatched April 30th is as follows:

TABLE GIVING WEIGHTS, AT VARIOUS DATES, OF THE DIFFERENT KINDS OF GOSLINGS HATCHED APRIL 30TH, 1894.

	JUNE 9, 1894.			JUNE 23, 1894.				JULY 7, 1894.			
	No. of Goslings.	Total.	Average.	No. of Goslings.	Total.	Average.	Gain.	No. of Goslings.	Total.	Average.	Gain.
African Toulouse	4	20.06	5.02	4	28.25	7.06	2.04	4	33.88	8.47	1.41
Embden African	5	24.00	4.80	5	36.63	7.33	2.53	5	40.88	8.18	.85
Wild Black African	5	23.44	4.69	5	33.81	6.76	2.07	5	38.06	7.61	.85
Pure Black African	2	8.94	4.47	2	13.13	6.57	2.10	3	24.13	8.04	1.47
Embden Toulouse	2	8.50	4.25	2	13.31	6.66	2.41	2	17.50	8.75	2.09
Embden Toulouse	8	34.00	4.25	8	50.81	6.35	2.10	6	48.00	8.00	1.65
Pure Embden	2	8.13	4.07	2	14.13	7.07	3.00	2	16.38	8.19	1.12
Toulouse Embden	2	7.19	3.60	2	10.75	5.38	1.78	2	12.81	6.45	1.07
Pure Toulouse	7	19.94	2.85	7	32.50	4.64	1.79	7	45.50	6.50	1.86
Prince Edward Island	2	5.06	2.53	2	9.13	4.57	2.04	2	9.19	4.60	.03
Pure Brown China	5	11.81	2.36	5	20.38	4.07	1.71	5	26.31	5.26	1.19
Pure Toulouse	8	16.44	2.06	7	23.88	3.41	1.35	7	31.00	4.43	1.02

TABLE GIVING WEIGHTS, AT VARIOUS DATES, OF THE DIFFERENT KINDS OF GOSLINGS HATCHED APRIL 30TH, 1894.

	JULY 21, 1894.				SEPT. 6, 1894.				DEC. 8, 1894.			
	No. of Goslings	Total.	Average.	Gain.	No. of Goslings.	Total.	Average.	Gain.	No. of Goslings.	Total.	Average.	Gain.
African Toulouse............	4	38.63	9.66	1.19	4	40.50	10.13	.47	4	53.63	13.40	3.27
Embden African.............	5	46.19	9.24	1.06	5	47.81	9.56	.32	5	64.50	12.90	3.34
Wild Black African..........	5	45.00	9.00	1.39	5	41.88	8.38	*.62	5	61.06	12.21	3.83
Pure Black African..........	3	29.44	9.81	1.77	3	30.88	10.29	.48	3	29.50	9.83	*.46
Embden Toulouse............	2	21.50	10.75	2.00	2	21.88	10.94	.19	2	27.50	13.75	2.81
Embden Toulouse............	6	54.69	9.12	1.12	6	56.81	9.47	.35	6	82.50	13.75	4.28
Pure Embden................	2	19.19	9.60	1.41	2	17.69	8.85	*.75	2	25.50	12.75	3.90
Toulouse Embden............	1	8.00	8.00	1.55	1	8.25	8.25	.25	1	10.50	10.50	2.25
Pure Toulouse...............	6	46.69	7.78	1.28	6	46.38	7.73	*.05	6	61.00	10.17	2.44
Prince Edward Island........	2	11.19	5.60	1.00	2	13.25	6.63	1.03	2	18.50	9.25	2.62
Pure Brown China...........	5	35.00	7.00	1.74	5	38.75	7.75	.75	5	51.50	10.30	2.55
Pure Toulouse.........	7	38.50	5.50	1.07	7	48.75	6.96	1.46	7	60.00	8.43	1.47

* Loss.

On June 9th, when a little over five weeks old, the African-Toulouse averaged the heaviest, the Embden-African next, the Wild-African cross third, the Pure African fourth, the Embden-Toulouse fifth and sixth, Pure Embden seventh, Toulouse-Embden eighth, Pure Toulouse ninth, and Pure Brown China tenth or least of all. Two weeks later the Embden-African stood first, Pure Embden second, African-Toulouse third, Wild-African fourth, Embden-Toulouse fifth, and Pure African sixth. At the first weighing the African-Toulouse were the heaviest, 5.02 pounds, but the Embden-African, 4.80 pounds, were nearly as heavy, and as they were white or nearly so and pick much easier than the former and look better when dressed, the Embden-African would have an advantage in the market. On June 23d Embden-Africans were the heaviest, 7.33 pounds, Pure Embdens second, 7.07 pounds, and African-Toulouse third. After the latter date the Toulouse blood had a strong influence and the Toulouse crosses forged ahead in size and weight while the Pure Embdens and other crosses were left behind. On July 7th the Embden-Toulouse (one lot) averaged 8.75 pounds, the African Toulouse 8.47 pounds, and the Embden-African averaged 8.18 pounds. This lead was held by the Embden-Toulouse the remainder of the season. In July and September the Pure African forged ahead of the Pure Embden and Embden-African cross. On December 8th the Embden-Toulouse weighed 13.75 pounds, the African-Toulouse 13.40 pounds, the Embden-African 12.90 pounds, and the Pure Embden 12.75 pounds. The Pure African then averaged as low as 9.83 pounds, and it was almost impossible to pick them without tearing the skin. Pure Africans were heavier and larger when hatched and when five weeks old than Embdens, Toulouse or Brown China, but at eight and ten weeks old were not as heavy as Pure Embdens. Previous to January 1st the Pure Toulouse did not grow as fast or as large as either of the other pure breeds. Crosses did better than pure breeds, and the influence of each breed (its characteristics) is seen in the time at which each cross leads or shows its best weight. The Embden-Toulouse shows to good advantage in this experiment and would appear to be the best all around cross for general purposes, for both early and late markets, and especially for the production of large geese for the Christmas or New Year's market. They are large, hardy, and when dressed are white and present a fine appearance.

Of those here compared the Embden-African cross seems to be next in desirability, and if the goslings are to be sold early in the summer, or before they are eight weeks old, this cross would be preferable to the others.

In weight and rapidity of growth the Wild-African compares favorably with the others. They are highly prized on account of their finer quality and flavor, and as they bring in the fall about double the price of common geese, they are the most profitable kind to raise, but success is more difficult to attain. Wild ganders do not mate until two or three years old and usually with but one goose. They must have a pond of water in the enclosure. They are very jealous of intrusion and fight other geese furiously at breeding time. Wild ganders should be mated to dark geese, either African, Toulouse or Brown China. These combinations resemble the wild. If crossed with white females and the goslings have white feathers, they may be discarded by marketmen or not accepted, as Mongrels. The young Mongrels fatten best after the weather becomes cold, and usually bring the highest price at Christmas. We know of four wild cross geese or Mongrels, so-called, being sold in December, 1895. They weighed twenty pounds each, dressed, and brought $20. The dealer who bought them shipped them to Europe to fill an order.

In this experiment the finest dressed goose as regards appearance was of the Pure Embden variety. The wild-cross birds were more plump and unusually fine but were darker skinned. The Toulouse-Embden cross were the least desirable of the crosses when dressed, but they were superior to the Pure Toulouse goslings, which were dark looking and much wrinkled unless very fat. These young geese could not be given as good pasturage as most farmers would have been able to give them. Doubtless their growth was retarded by their being repeatedly caught and weighed, although this was not done as frequently as with those of the previous season. Doubtless some breeds, the more active kinds, were better able to stand the concentrated food given them than the more sluggish kinds whose growth may have been stunted. All kinds were allowed to run together, and the same objection applies in this case as was noted in connection with our first season's experiment with geese. The loss noted in the table is probably due to the goslings becoming fat and shedding their feathers, or by their having greater freedom to range. It would seem doubtful policy to keep early hatched goslings, Mongrels excepted, for the Christmas market. Like roasting chickens they bring more in June and July than if sold later. Although they may have doubled in weight they bring much less.

The following tables show the relative weights of the pure breeds and crosses as they compared with each other at five, eight, ten, twelve and fourteen weeks, as well as at seven months of age:

EARLY GROWTH.

AVERAGE AT FIVE WEEKS.

African-Toulouse Cross	5.02 lbs.	Pure Embden	4.07 lbs.
Embden-African Cross	4.80 lbs.	Toulouse-Embden Cross	3.60 lbs.
Wild-African Cross	4.69 lbs.	Pure Toulouse	2.85 lbs.
Pure African	4.47 lbs.	Prince Edward's Island	2.53 lbs.
Embden-Toulouse Cross	4.25 lbs.	Pure Brown China	2.36 lbs.

AVERAGE AT EIGHT WEEKS.

Embden-African Cross	7.83 lbs.	Pure African	6.57 lbs.
Pure Embden	7.07 lbs.	Toulouse-Embden Cross	5.38 lbs.
African-Toulouse Cross	7.06 lbs.	Pure Toulouse	4.64 lbs.
Wild-African Cross	6.76 lbs.	Prince Edward's Island	4.57 lbs.
Embden-Toulouse Cross	6.66 lbs.	Pure Brown China	4.07 lbs.

SUMMER GROWTH.

AVERAGE AT TEN WEEKS.

Embden-Toulouse Cross	8.75 lbs.	Wild Black-African Cross	7.61 lbs.
African-Toulouse Cross	8.47 lbs.	Pure Toulouse	6.50 lbs.
Pure Embden	8.19 lbs.	Toulouse-Embden Cross	6.45 lbs
Embden-African Cross	8.18 lbs.	Pure Brown China	5.26 lbs.
Pure African	8.04 lbs.	Prince Edward's Island	4.60 lbs.

AVERAGE AT TWELVE WEEKS.

Embden-Toulouse Cross	10.75 lbs.	Wild-African Cross	9.00 lbs.
Pure African	9.81 lbs.	Toulouse-Embden Cross	8.00 lbs.
African-Toulouse Cross	9.66 lbs.	Pure Toulouse	7.78 lbs.
Pure Embden	9.60 lbs.	Pure Brown China	7.00 lbs.
Embden-African Cross	9.24 lbs.	Prince Edward's Island	5.60 lbs.

AVERAGE AT FOURTEEN WEEKS.

Embden-Toulouse Cross	10.94 lbs.	Wild-African Cross	8.38 lbs.
Pure African	10.29 lbs.	Toulouse-Embden Cross	8.25 lbs.
African-Toulouse Cross	10.18 lbs.	Pure Brown China	7.75 lbs.
Embden-African Cross	9.56 lbs.	Pure Toulouse	7.73 lbs.
Pure Embden	8.85 lbs.	Prince Edward's Island	6.63 lbs.

FALL GROWTH.

AVERAGE AT SEVEN MONTHS.

Embden-Toulouse Cross	13.75 lbs.	Toulouse-Embden Cross	10.50 lbs.
African-Toulouse Cross	13.40 lbs.	Pure Brown China	10.30 lbs.
Embden-African Cross	12.90 lbs.	Pure Toulouse	10.17 lbs.
Pure Embden	12.75 lbs.	Pure African	9.83 lbs.
Wild-African Cross	12.21 lbs.	Prince Edward's Island	9.25 lbs.

INDIVIDUAL LIVE AND DRESSED WEIGHTS OF SELECTED SPECIMENS EXHIBITED AT THE WINTER SHOW OF THE R. I. POULTRY ASSOCIATION, DECEMBER 11TH TO 14TH, 1894.

PARENTAGE.	Live weight.	Dressed weight.	Shrinkage.	Per cent. of shrinkage.
Pure African	15.25	14.25	1.00	6.56
Embden-Toulouse	14.94	13.50	1.44	9.64
Embden-African	14.19	13.00	1.19	8.39
Embden-African	14.00	12.63	1.37	9.79
Embden-African	13.69	12.50	1.19	8.77
Pure Embden	13.69	12.44	1.25	9.13
Wild-African	13.68	12.93	.75	5.58
African-Toulouse	13.44	12.44	1.00	7.44
African-Toulouse	12.94	11.81	1.13	8.73
Embden-African	12.88	11.75	1.13	8.77
Pure Embden	12.75	11.63	1.12	8.78
Wild-African	12.13	11.31	.82	6.76
Pure Toulouse	11.19	10.69	.50	4.47
Pure Toulouse	11.13	10.06	1.17	10.51
Toulouse-Embden	11.00	10.00	1.00	9.09
Pure Brown China	10.19	9.19	1.00	9.81

There was a great difference in size between the Pure African here recorded and the two shown alive.

As might be expected both of the Wild-African crosses shrunk very little in dressing. One Toulouse shrunk the least and the other the most. The Pure African shrunk very little and less than the Embdens. The African-Toulouse cross shrunk less than the Embden-Toulouse. However, the amount of shrinkage depends somewhat upon whether the picker bleeds the bird slightly or thoroughly.

The following notes on the appearance of the goslings were taken on July 7th:

EMBDEN-TOULOUSE. Bill and legs yellow. Eyes blue. In plumage three are almost wholly of a light slate and same number nearly clear white.

AFRICAN-TOULOUSE. Some have black bills and others dull yellow bills. The bills are dark at first and later change to dull yellow the same as the Toulouse. Part have African plumage and the remainder have Toulouse markings. They look larger than Toulouse or Pure African.

PURE EMBDENS. Very large and fine. Bill and legs yellow. Eyes blue. Plumage pure white. Ends of wings reach end of tail.

EMBDEN-AFRICAN. Resemble Embden more than African. Very plump and compact. Bill and legs yellow. Eyes blue. Plumage both pure white and slate color. About half are mostly white. Wings reach tail.

PURE AFRICAN. Bill black. Eyes dark brown. Legs dark. Plumage light gray with black strip on back of neck.

WILD AFRICAN. Eyes dark brown. Bill and legs black. Neck long and swan-like. Plumage black. Head black with light patch on cheek or just back of the eyes. Back dark brown, breast light slate color, abdomen white. Tail and wing flights black.

PURE TOULOUSE. Dark gray, small.

TOULOUSE-EMBDEN. One looks like a clear Embden and the other like a pure Toulouse. Small in size.

PURE BROWN CHINA. Bill black. Eyes dark brown. Legs dull brownish orange. Plumage gray with black stripe on back of neck.

PRINCE EDWARD'S ISLAND. Small in size and one quite light in weight. Bill and legs yellow. Color of plumage, slate and white pied.

THIRD SEASON'S EXPERIMENT.

1895.

As the two seasons' experiments with geese were made secondary to the work with turkeys and fowls, they could not be carried on under the most favorable circumstances nor be made as complete and extensive as was desired. The breeding geese were not given as much space in their pens nor as much pasturage as they should have had. We were also unable to give the young geese the kind and amount of pasturage that would have favored the quickest growth or the very largest size.

White China geese or their crosses were not included in these tests, and there were several other possible crosses or combinations of the African, Embden, Toulouse and Brown China breeds that had not been compared. Of those compared some kinds were represented by but one or two specimens. For these reasons it seemed very desirable that there should be a repetition of the work under more favorable circumstances to verify what had been done as well as to test the other breeds and crosses.

It was also deemed important that the number of eggs laid by each breed should be ascertained, as well as which breeds or cross-matings produced the greatest number of fertile eggs.

Although the extent of the proposed experiment and the amount of careful work which would be necessary to properly carry it out in all its details, would prevent this Division from taking up any other important experiments, it was decided to undertake the work.

Extra breeding geese were required, and considerable trouble was had in securing fine specimens. Africans particularly were hard to secure, as well as White Chinas and really fine Embdens.

Toulouse geese of high quality were more plenty. Our work as Secretary of the R. I. Poultry Association delayed us in looking them up early in the fall. Had we undertaken to secure fifty fine specimens each of twenty of the most popular breeds of fowls and fine specimens of all the varieties of turkeys and ducks, we could have secured them with much less trouble and delay.

Most of them were secured in October and January, but some were not obtained until the last of February and the middle of March. The College dormitory having been destroyed by fire in January, a new building was soon after constructed to replace it. As the granite used for building purposes is quarried from a ledge on the Poultry Division grounds, it suddenly became necessary to open the ledge in the vicinity of our breeding pens just at the mating and laying time for geese. In this work huge charges were fired which blew off the side of the ledge for a distance of thirty or forty feet. The blasts were so heavy that windows in our feed room, fifty feet away, were completely shattered, both glass and sash. In one case eggs in incubators 150 feet away were piled in heaps. In addition to the blasts and the fragments of stone falling in the yards, was the constant working of the steam derrick and the activity of the stone workers in sight of and near the geese, keeping them in a state of excitement. The impossibility of great success will be understood by experienced geese raisers, who know that geese or goslings will not thrive well if cared for by a nervous, quick-motioned attendant who frightens them.

When received, the new geese were temporarily placed in buildings or small enclosures while being mated. They were put together in trios, one gander and two geese in each pen. Not every attempt at late mating was a success.

The size of many of the yards given them was larger than those of the previous season, but on account of the blasting a number of new pens, 25x25 feet, were built early in May, and part of the geese removed to them.

The fact that some of the geese had been on the place two years and others were received about laying time, as well as that they were so frequently frightened, would make the egg record of little value. The following table, however, shows the average egg yield as well as the make-up of the various pens:

NUMBER OF EGGS LAID BY GEESE CONFINED IN SMALL YARDS UNDER UNFAVORABLE CIRCUMSTANCES.—SEASON OF 1895.

YARD.	MALES.	FEMALES.	Total Egg Yield.	Average Egg Yield.	Earliest Egg Laid.	Last Egg Laid.
15	Embden..............	2 Toulouse............	*63	31½	Feb. 26	June 10
7	African................	2 Toulouse............	19	9½	Mar. 14	May 17
6	Brown China.........	2 Toulouse............				
20	Embden..............	1 Brown China.......	7	7	Mar. 9	April 4
10	Toulouse..............	2 Brown China.......	36	18	Mar. 21	June 24
16	African................	2 Brown China.......	59	29½	Mar. 4	June 10
3	Brown China.........	2 Brown China.......	37	18½	Feb. 26	May 27
5	Embden..............	2 Embdens............	28	14	Feb. 20	May 10
18	Toulouse..............	2 Embdens............	25	12½	Mar. 23	May 21
13	African................	2 Embdens............	24	12	Feb. 9	April 18
8	Brown China.........	2 Embdens............	22	11	Mar. 28	May 4
17	White China..........	2 Embdens............	16	8	Mar. 29	May 12
12	Embden..............	2 African.............	26	13	Jan. 25	April 25
19	Toulouse..............	2 African.............	13	6½	Mar. 13	April 11
9	African................	2 African.............	12	6	Feb. 27	April 11
4	Brown China.........	2 African.............	8	4	Feb. 25	Mar. 18
2	Embden..............	1 White China........	20	20	Mar. 7	May 23
22	Prince Ed'ard's Isl'nd	2 Prince Ed'rd's Isl'nd	5	2½	Mar. 13	April 1
			420			

* Yard No. 15 was sufficiently large (150 x 280 feet), contained a pool and meadow grass and was most distant from the ledge. These birds had also been mated up and bred from the two previous seasons.

The eggs were hatched both in incubators and under hens. Not only was the per cent. of fertility low, of the eggs secured, but the goslings hatched seemed weak and many died or lost the use of their legs. The first lot artificially incubated gave a greater per cent. of goslings than those hatched under hens. Of the first lot of 165 eggs set March 19th, 65 eggs were fertile. Of the 33 in the incubator 25 goslings were hatched. From the 32 under hens but 13 goslings were secured, a number being trampled to death in the nest. Of the 38 goslings of this lot 9 died during the first eight days. The goslings hatched in incubators seemed unusually weak.

Later lots of eggs in incubators were so jarred and moved by some of the blasts at the quarry that successful incubation was impossible. As the goslings secured from the several hatches were from but a few pens and it was then impossible to secure enough from other pens to make a comparison it was useless to carry out the experiment as planned, therefore the goslings were not weighed until the end of the season, when they were shut up to be fattened, and when they were dressed for market. During the summer they were given free range over the poultry division grounds where grass was abundant, and were fed with cracked corn. When they were shut up in a building to fatten on November 23d, Mr. Salter weighed a good specimen of each of the crosses, and their weights were as follows:

	lbs.	oz.		lbs.	oz.
Embden-Toulouse...........	17	3	Embden-White China........	13	00
Embden-Toulouse...........	17	2	African-Brown China.......	12	10
Brown China............ ...	13	14	African-Toulouse............	12	8
Embden-African	13	13	Pure African................	12	8

While confined in a building to fatten they were fed scalded corn meal and beef scraps three times daily. As they were taken from the fields where they had free range it was some time before they became reconciled and began to take on fat, and when dressed 16 days later very little gain had been made. If shut away from grass and fed out in the open air, they would have been less disturbed and would have commenced earlier to gain. The building was probably too close for them although the windows were left open. As it was, a week longer in the fattening house would have been better. On December 9th they, and a lot of cross-bred geese kept over from the previous season, were dressed for the Poultry Exhibition and their weights were as follows:

INDIVIDUAL LIVE AND DRESSED WEIGHTS OF YOUNG GEESE EXHIBITED AT THE WINTER SHOW OF THE RHODE ISLAND POULTRY ASSOCIATION, TAKEN DECEMBER 9TH, 1895.

PARENTAGE.	LIVE WEIGHT.	DRESSED WEIGHT.
	lbs.	lbs.
Embden-Toulouse	17 75	16.44
Embden-Toulouse	17.31	16.13
Pure Toulouse	15.00	13.75
Embden-African	14 56	13.50
African-Toulouse	14.00	12.88
Pure Toulouse	13.69	12.69
Pure Toulouse	13.75	12.69
Pure Brown China	13.38	12.31
Embden-White China	12.63	11.50
African-Brown China	12.50	11.69
African-Brown China	12.50	11.44
Pure African	12 38	11.38
Pure Toulouse	12.25	11.38
Embden-White China	11 69	10.69
African-Brown China	11.19	10.38
African-Brown China	11.13	10.13
African-Toulouse	11.06	10.38
African-Brown China	11.00	10.00
African-Brown China	10.63	9.75
African-Brown China	10.38	9.63
Embden-White China	10.31	9.38
African-Brown China	10.25	9.25
Pure Brown China	9.44	8.75
African-Brown China	9.75	9.00
African-Brown China	9.75	9.00
African-Brown China	9.69	9.00
Embden-White China	9.63	9.00
African-Brown China	9.63	8.56
African-Brown China	8.81	8.19
African-Brown China	8.75	8.13

Individual Live and Dressed Weights of Yearling Geese Exhibited at the Winter Show of the Rhode Island Poultry Association, taken December 9th, 1895.

Parentage.	Live Weight.	Dressed Weight.
	lbs.	lbs.
Embden-Toulouse	13.88	11.94
African-Toulouse	13.00	12.00
Pure Toulouse	12.50	11.25
Pure Toulouse	12.50	11.50
Embden-Toulouse	12.25	11.25
Embden-Toulouse	11.94	10.94
Embden-Toulouse	11.81	10.69
African-Toulouse	11.75	10.63
Pure Toulouse	11.75	10 63
Pure Toulouse	11.63	10.50
Embden-Toulouse	11.63	10.44
Pure Toulouse	11.50	10 75
Pure Toulouse	11.50	10.56
Prince Edward's Island	11.00	9.88
Prince Edward's Island	10.88	9.94
Prince Edward's Island	10.88	9.63
Prince Edward's Island	9.81	8.81
Prince Edward's Island	9.50	8 50
Prince Edward's Island	9.44	8.50

It will be noticed that the Embden-Toulouse cross of this season lead in weight those of last season. At this time all Africans and Brown China geese dressed dark and were very hard to pick. The Toulouse also dressed dark and wrinkly, except those that were very fat, but were not hard to pick. The African-Toulouse cross were dark when dressed, but not so hard to pick as the pure Africans. The African-Brown China cross was plump and tender but were hardest of all to pick, and looked worst when dressed. The Embden-African cross were very easy to pick, light colored when dressed, and large, plump and handsome. The Embden-White China cross picked the easiest of these crosses, were white when dressed, and although small, were very plump, and presented the most attractive appearance. The Embden-Toulouse cross were large, white or yellow when dressed, but were not quite equal to Embden-Africans or Embden-White Chinas in plumpness or attractiveness. Mr. Pettee, buyer of poultry for the Providence Public Market, pronounced the Embden-White China cross very plump, fine grained and attractive, preferable in size for his family trade, and worth to him several cents more per pound than the larger birds.

White China geese are the smallest and weakest of all breeds, but lay early and late in the season a great number of large eggs, and if mated with the Embden ganders produce vigorous, quick-growing goslings, which are very plump and solid. Whether as large a proportion of fertile eggs will be secured as from other matings, or a proportionate number of goslings produced one season with another, is an interesting question that we hope to be able to test and answer later.

For trade that requires a large goose at Christmas or New Year's, the Embden-Toulouse would be most suitable of these crosses. Pure Africans, Embden and Embden-African crosses get their best growth early in the season and should be sold early. Pure Brown Chinas, African-Toulouse and African-Brown China crosses should be dressed before fall in order that they may pick well. In the fall it is hard to dry pick the feathers from the latter without picking them all to pieces, and it is frequently necessary to use scalding water to entirely remove their feathers. The white plumaged Embden and the crosses that are white are comparatively easy to pick even in the fall.

There is so little reliable information published on raising geese that the beginner, unable to secure the advice of an experienced raiser, is usually all at sea in regard to how to proceed. Misled by what he reads, he is apt to conclude, after one or more seasons, that geese are unprofitable and give up keeping them. We therefore give place to the following, learned from the failures as well as the successes of several seasons.

Although old geese lay a greater number of larger eggs, and are more reliable breeders, it is not always best to attempt to buy old geese. Owners are unwilling to part with well tried breeders that are really profitable, as it pays better to keep them than to sell them at what would be considered a reasonable price. Quite often the old geese offered for sale are those found to be unprofitable. It is therefore usually better policy and saves time to buy young geese before they are killed for market, rather than to attempt to secure any number of old geese.

Most breeders dress their goslings for market or sell them to fatteners in June and July when they bring the most, considering the time and feed given, rather than grow them to maturity and take the chance of selling them at a slight advance for breeding purposes; therefore, it is best to place orders in the spring or early summer, for young stock to be delivered in the fall. Young ganders are better for breeding than young geese. Ganders not over five or eight years old, mated to old geese, give the best results. Young geese do not lay as many fertile eggs and produce as many goslings the first breeding season as they do the second season. If geese, whether young or old, are changed from one place to another after January first they are liable not to breed well that season, and they breed better the third season they are on a place than they do the second season, all other conditions being equal. Therefore, breeding geese should be secured as early in the fall as possible, not later than October, to insure the best results. This gives them sufficient time to become acquainted with their new surroundings and feel thoroughly at home before the breeding season. It is also well to have at this date all birds which are to be mated, penned or yarded by themselves. Breeding geese should be kept active and moderately thin in flesh through the winter by light feeding, and by allowing them free range, or such facilities for swimming as will induce them to take much exercise. If deprived of the latter they must not be fed much fattening food. They require no houses or protection from cold or storm and seem to prefer to stand out exposed to the wind in mid-winter rather than seek the protection of an open shed except during a heavy snow storm.

Geese are grazers as much as cows and can be spoiled by too much grain. To insure the fertility of eggs, access to a pond, puddle or a tub of water set level with the ground, as well as an abundance of green food is of the greatest importance.

African and Brown China ganders mate more quickly than other kinds and are the most prolific and sure breeders. Toulouse ganders are sluggish, slow to mate and as breeders are the least reliable. Toulouse geese are great layers and some specimens do not offer to sit. Embden geese are more inclined to sit than Toulouse and make better mothers but lay fewer eggs. Brown China and White China geese are very prolific layers. Very early laying is not desirable, as goslings hatched before grass is plenty do not do well and cost more than they bring. Goslings do best when put out during the day on short grass with water to drink, no other food but grass being given for two days and then a light feed of scalded cracked corn three times daily in addition to the grass. The supply of grass should always be ample and the water dish should never become empty. They should always have an opportunity to get into the shade or they are liable to be overcome by the heat of the sun. If hurdled on fresh green sward daily and kept in a rat-proof house at night, they grow more uniformly and less are lost than if brooded by geese or hens. They should be managed so that they will be active and eager for food most of the time.

Next season this experiment with geese will again be undertaken. We plan to raise sixteen different crosses and five different pure breeds instead of fourteen crosses and four pure breeds as planned last season. The extra old geese required as well as those procured to replace a few inferior specimens kept last year are secured and were on the place before December 1st. Instead of being confined in small yards each trio has been provided with a pen 60 x 60 feet. Within each pen there will be a bathing place or water hole and barrels for nests. The eggs will be hatched under hens but the goslings will be immediately taken away from them. They will be brooded for a short time in out door brooders and after that shut up in large houses at night. During the day they will be hurdled on ample grass pasturage and on various succulent green crops grown especially for them. It is proposed to weigh them but once before they reach marketable age and then take the weights of each cross occasionally for comparison. The goslings will be dressed at different times and sent to city markets, also sold to dealers and fatteners to learn their opinion as to their relative merits. This experiment is expected to throw more light on which pure breed lays the greatest number of eggs; which the smallest number of eggs; which average the largest eggs; which average the smallest eggs; which pure breed gives most fertile eggs; which cross-mating gives most fertile eggs; which breed of ganders gives the best result as to fertile eggs; which ganders give worst result as to fertile eggs; which goslings are the hardiest; which are the least hardy; which pure bred gosling matures earliest; which pure bred gosling makes largest Christmas goose; which is the best pure breed for market production; which is the most profitable to produce, pure breeds or crosses; which is the best cross for early goslings; which is the best cross for late goslings of medium size; which the best cross for late goslings of large size; which breed or cross breed picks the easiest; which the hardest; which looks best when dressed; which looks worst when dressed; which sells best alive to fatteners; which sells least readily; which brings most when sold to marketmen; which brings least when sold to marketmen; and which cross-mating produces the largest number of saleable goslings when they bring the best price.

METEOROLOGICAL REPORT.

NATHANIEL HELME.

Soon after making the last annual report a number of meteorological instruments consisting of a Draper's thermograph and barograph, also a self-recording anemometer, anemoscope, raingauge and sunshine recorder with quadruple register, were purchased by the College for use by the meteorologist, but before they were fully in working order they were lost or damaged in the fire which destroyed College Hall. The quadruple register, being in the lower part of the building was saved, but the barograph was injured in its hasty removal. The thermograph not being near the building was not injured. In addition to these there is a Lambrecht's Polymeter which registers the percentage of the humidity of the air. It has proved to be a very good instrument and is more sensitive to the changes of moisture in the atmosphere than is the ordinary wet bulb thermometer. The other instruments remain the same as last year. During the growing season, weekly reports of the effect of the weather on crops, their condition and progress, have been sent to the Director of the New England Weather Service in Boston. Beginning in December 1895, each Monday afternoon reports of the depth of snow on the ground have been sent to the same place. Other duties performed have been the daily display of weather signals, furnishing the daily forecasts for publication in the Evening Bulletin of Providence, and the monthly weather summaries in the Journal and Bulletin, and also in the Narragansett Times.

Summary for 1895.

Maximum temperature	95°	June 2.
Minimum temperature	—7°	February 6.
Range for the year	102°	
Mean temperature for the year	48.2°	
Highest monthly mean	69.4°	August.
Lowest monthly mean	21.7°	February.
Highest daily mean	79°	June 2.
Lowest daily mean	1°	February 8.

Precipitation.

Total for the year (rain and melted snow)	49.28	inches.	
Largest total for one month	7.89	"	October.
Least total for one month	1.29	"	September.
Greatest precipitation in 24 consecutive hours	4.	"	Oct. 12–13.
Total snowfall for the year	40½	"	
Largest total for one month	16	"	January.
Least total for one month	5	"	March.

Weather.

Number of clear days in the year	128
Number of fair days in the year	114
Number of cloudy days in the year	123
Number of days with precipitation of .01 inch or more	108

Prevailing Winds.

N. 1 month. E. 1 month. S. W. 5 months. W. 5 months.

Atmospheric Pressure in Inches.

(Not reduced to sea level and 32° temperature.)

Maximum pressure	30.56	inches.	December.
Minimum pressure	28.49	"	February.
Mean pressure	29.83	"	

Summary 1890 to 1895 Inclusive.

	1890.	1891.	1892.	1893.	1894.	1895.
Maximum temperature......	91°	94°	92°	92°	93°	95°
Minimum temperature......	3°	5°	—1°	—6°	—9°	—7°
Mean temperature..........	48.3°	49.4°	47.8°	46.5°	48.6°	48.2°
Total precipitation, inches..	59.25	49.88	42.58	57.33	48.19	49.28
Number of clear days......	99	116	147	126	110	128
Number of fair days.........	143	154	116	130	130	114
Number of cloudy days......	123	95	103	109	125	123
Number of days with precipitation .01 inch or more..	120	83	89	131	114	108

Average mean temperature, 48.1°.

Average precipitation, 51.08 inches.

Comparing the weather conditions of each month with those of previous years it is found that the mean temperature for *January* was a little below the average, as was also the precipitation. The severest storm of the month occurred on the 26th, when five barges were wrecked on Point Judith. On the 27th when College Hall was burned the wind was blowing at the rate of 40 miles an hour, and pieces of charred paper from the burning building were picked up in places two miles away.

February was a cold month, the mean temperature being the lowest for the month since the record was kept here. The larger part of the precipitation was in the form of snow, there having been but one rain storm during the month.

March temperature and precipitation were below the average for the month. The ground was bare of snow the greater part of the time but the frost prevented any ploughing.

The temperature of *April* was about the average and the precipitation was the largest during seven years, being nearly two inches more than the average.

May temperature was about the average, though there were several killing frosts during the month, making it necessary to replant crops in some places. The rainfall was a little below the average. The month ended with excessive heat, the temperature of 91° on the 31st being the highest for May that has been recorded here.

June opened with very high temperature, the maximum of the month being registered on the 2d, which was also the hottest day of the summer. The middle of the month was cooler, a light frost being reported from some exposed places on the 17th. The rainfall was above the average and nearly eight times that of June, 1894.

July mean temperature was the lowest, with one exception, since the record was kept here, and the precipitation was the largest since 1889, it being about two inches more than the average and four times that of July, 1894. The cloudy and wet weather had a bad effect on the berry crop and caused potato blight in a number of places. It was very nearly the end of the month before the hay crop was secured.

August temperature and rainfall were about the average. There were no severe storms during the month. White frost formed on low lands on the morning of the 22d.

September was warm and dry, the maximum temperature being greater than at any time during the summer with the exception of the first part of June. The rainfall was only about one-third of the average for the month. The weather on the whole was very favorable to the maturing and harvesting of crops.

The mean temperature of *October* was below the average, and the rainfall slightly above. The first killing frost formed on the 9th, and there was a slight flurry of snow on the 21st. On the 12th and 13th there was a heavy rain storm, four inches of water falling within 24 hours. Taken altogether it was a month of fine autumn weather.

The high temperature of *November* makes it one of the warmest on record. For several days there were dense fogs. The temperature was above the average and the rainfall a little below.

December was also a warm month, the mean temperature being the highest since 1891, and the rainfall, with one exception (December 1892), the least for any December since the record has been kept here. There was no frost in the ground at the end of the month. Six inches of snow fell during the month but it remained on the ground for a short time only.

The last frost in the spring formed May 19th and the first autumn frost August 22d, the first killing frost September 15th.

The last snow fell March 30th and the first of the winter December 5th.

The mean relative humidity for each month of 1895 has been as follows:

January	77.7	per cent.	July	68.8	per cent.
February	72.9	"	August	82.	"
March	75.1	"	September	76.8	"
April	78.7	"	October	75.1	"
May	80.6	"	November	82.7	"
June	84.5	"	December	76.7	"

Average, 77.6 per cent.

METEOROLOGICAL SUMMARY.

	JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.	
	1895.	1894.	1895.	1894.	1895.	1894.	1895.	1894.	1895.	1894.	1895.	1894.
Temperature.												
Maximum	52.°	52.°	47.°	47.°	52.°	60.°	68.°	74.°	91.°	87.°	95.°	93.°
Minimum	3.°	4.°	—7.°	—9.°	15.°	14.°	23.°	18.°	30.°	35.°	46.°	42.°
Mean	26.9°	29.5°	21.7°	24.9°	33.6°	40.°	43.8°	44.5°	55.8°	56.1°	66.2°	66.2°
Air pressure in inches.												
Maximum	30.26	30.35	30.25	30.54	30.25	30.29	30.49	30.24	30.20	30.22	30.26	30.08
Minimum	29.05	28.55	28.49	28.96	29.08	29.35	29.15	29.50	29.35	29.36	29.62	29.45
Mean	29.81	29.86	29.64	29.90	29.75	29.89	29.81	29.83	29.85	29.78	29.89	29.80
Precipitation in inches.												
Rain and melted snow	4.94	4.63	1.75	4.95	4.00	1.98	6.54	4.07	4.28	4.00	3.83	.50
Snow fall	16	24½	13½	24	5	4	......	11	......	......	......	......
Weather.												
No. of clear days	9	9	13	7	13	8	11	9	9	10	6	5
No. of fair days	11	9	9	10	7	14	5	7	9	11	10	11
No. of cloudy days	11	13	6	11	11	9	14	14	13	10	14	14
No. of days with precipitation of .01 inch or more	14	11	6	11	14	8	12	10	10	11	8	7
Prevailing wind	W.	S.W.	W.	W.	W.	W.	W.	S.W.	S.W.	E.	E.	S.W.

METEOROLOGICAL SUMMARY.—CONTINUED.

	JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	1895.	1894.	1895.	1894.	1895.	1894.	1895.	1894.	1895.	1894.	1895.	1894.
Temperature.												
Maximum	87.°	98.°	87.°	85.°	94.°	85.°	70.°	70.°	72.°	68.°	57.°	55.°
Minimum	48.°	49.°	45.°	42.°	37.°	39.°	26.°	32.°	15.°	11.°	8.°	6.°
Mean	67.4°	72.1°	69.4°	65.°	64.5°	64.5°	47.1°	52.5°	42.7°	36.9°	33.6°	31.4°
Air pressure in inches.												
Maximum	0.02	30.18	30.09	30.02	30.14	30.37	30.40	30.20	30.44	30.40	30.56	30.30
Minimum	29.56	29.64	29.55	29.62	29.53	29.58	29.25	29.03	28.99	29.41	29.12	29.23
Mean	29.78	29.88	29.81	29.85	29.87	29.98	29.82	29.77	29.97	29.88	29.91	29.89
Precipitation in inches.												
Rain and melted snow	5.36	1.85	2.70	2.74	1.29	3.96	7.89	9.14	4.25	5.26	2.45	5.66
Snow fall	......	......	......	......	......	......	......	.....	Trace.	6½	6	5½
Weather.												
No. of clear days	9	10	11	10	15	7	15	11	9	13	8	11
No. of fair days	13	15	13	10	5	11	11	11	10	8	11	13
No. of cloudy days	9	6	7	11	10	12	5	9	11	9	12	7
No. of days with precipitation of .01 inch or more.	9	5	6	8	4	8	6	11	10	12	9	12
Prevailing wind	S.W.	S.W.	S.W.	W.	S.W.	S.W.	W.	S.W.	S.W.	W.	N.	W.

EXCHANGES AND DONATIONS.

Copies of the following Agricultural and other papers have been regularly received at this office, where they are kept on file for reference:

The American Fertilizer, Philadelphia, Pa.
The Agricultural Epitomist, Indianapolis, Ind.
The American Agriculturist, New York, N. Y.
The American Cultivator, Boston, Mass.
The American Florist, Chicago, Ill.
The American Grange Bulletin and Scientific Farmer, Cincinnati, Ohio.
The Baltimore Weekly Sun, Md.
The California Cultivator, Los Angeles, Cal.
The Connecticut Farmer, Hartford, Conn.
Elgin Dairy Report, Elgin, Ill.
Farm, Field and Fireside, Chicago, Ill.
Farmer's Guide, Huntington, Ind.
Farmer's Magazine, Springfield, Ill.
Garden & Forest, New York, N. Y.
Grange Visitor, Lansing, Mich.
Hoard's Dairyman, Fort Atkinson, Wis.
Home and Farm, Louisville, Ken.
Hope Valley Advertiser, Hope Valley, R. I.
Hope Valley Free Press, Hope Valley, R. I.
Industrial American, Lexington, Ky.
Mirror & Farmer, Manchester, N. H.

Montana Fruit Grower, Missoula, Mont.
Nebraska Farmer, Lincoln, Neb.
New England Farmer, Boston, Mass.
Oregon Agriculturist, Portland, Oregon.
Pacific Coast Dairyman, Tacoma, Wash.
Practical Farmer, Philadelphia, Pa.
Pomona Herald, Pascoag, R. I.
The Southern Planter, Richmond, Va.
Toledo News, Toledo, Ohio.
The Vermont Farmer's Advocate, Burlington, Vt.
Wallace's Farmer and Dairyman, Ames, Iowa.
The National Provisioner, New York, N. Y.
The Holstein Friesian Register, Boston, Mass.
The Louisiana Planter, New Orleans, La.
The Southern Cultivator and Dixie Farmer, Atlanta, Ga.
The Sugar Beet, Philadelphia, Pa.
Sentinel Advertiser, Hope Valley, R. I.
The New Dairy, New York, N. Y.
The Naturalist's Leisure Hour, Philadelphia, Pa.
The American Horse Breeder, Boston and New York.
Western Farmer and Stockman, Sioux City, Iowa.
The Dorset Quarterly, Washington, Pa.
American Fancier, Johnstown, N. Y.
Ohio Poultry Journal, Dayton, Ohio.
New England Fancier, Danielsonville, Conn.
Poultry Inter-Ocean, Decatur, Ill.
Poultry Monthly, Albany, N. Y.
The Fancier's Review, Chatham, N. Y.
American Stock Keeper, Boston, Mass.
Farm Poultry, Boston, Mass.
Feathered World, London, England.
Plymouth Rock Monthly, Boston, Mass.
Poultry News, Lincoln, Neb.
The Practical Poultryman, Whitney's Pt., N. Y.
Colorado Poultry Journal, Denver, Colo.

Reliable Poultry Journal, Quincy, Ill.

Numerous reports and publications of the U. S. Government Department of Agriculture and other departments have been received, as well as all bulletins and reports from all the Experiment Stations in the United States, and some from Canada and New South Wales.

THE FOLLOWING BOOKS HAVE BEEN RECEIVED.

Third Biennial Report Oregon State Board of Horticulture, Henry E. Dosch.

Report on Experiments with Potatoes and Onions in Warminster and District, E. S. Beaven.

Zwischenfruchtbau auf leichem Boden, German Kali Works.

Ninth Biennial Report Kansas State Board of Agriculture, F. D. Coburn, Sec.

Report of the Commissioner of Education, 1891–92, Vols. I and II, Wm. T. Harris, L.L. D., Commissioner of Education, Washington, D. C.

Sixth Report Missouri Botanical Garden, William Trelease, Director.

Magner's Story of Twenty Years a Horse Tamer, The Magner Book Pub. Co.

Report of the Chief of Weather Bureau, U. S. Department of Agriculture.

Memoranda of the Origin, Plan, and Results of the Field and Other Experiments Conducted on the Farm and in the Laboratory of Sir John Bennet Lawes, Bart., D. C. L., L. L. D., Sc. D., F. R. S., at Rothamsted, Herts.

Facts for Horse Owners, illustrated, D. Magner.

Eighth Report of the State Board of Health of the State of Maine, 1892–'93.

Annual Report Ontario Department of Agriculture, Vols. I and II, John Dryden, Minister of Agriculture.

Report of the Ohio Food and Dairy Commissioner, Dr. F. B. McNeal.

Special Report on Bovine Tuberculosis, Florence Hull Watson, M. D.

Transactions of the Mass. Horticultural Society for the year 1894, Part II, Robert Manning, Sec.

Wisconsin Farmers' Institutes, a Hand-book of Agriculture, Bull. No. 9, Geo. McKerrow, Supt.

Eighth Annual Report of the Commissioner of Industrial Statistics, Henry E. Tiepke, Commissioner.

OTHER DONATIONS.

One quart each of two varieties of cowpeas, Maryland Agricultural Experiment Station.

One package Wax Bush Beans, (No. 71), A. N. Jones, Newark, N. J.

Two packages seeds, Delano Moore, Presque Isle, Me.

Forty packages seeds, Hiram W. Buckbee, Rockford, Ill.

Strawberry plants, M. Crawford.

Gooseberry plants, A. L. Wood.

Sugar Beet Seeds, Franz G. Zimpel.

REPORT OF THE TREASURER.

MELVILLE BULL.

THE RHODE ISLAND AGRICULTURAL EXPERIMENT STATION *in account with the* UNITED STATES APPROPRIATION.

1895.	Dr.		
	To receipts from the Treasurer of the United States as per appropriation for the year ending June 30, 1895, under act of Congress approved March 2, 1887		$15,000 00
1895.	Cr.		
June 30.	By Salaries	$8,591 50	
	Labor	2,194 45	
	Publications	850 26	
	Postage and stationery	123 25	
	Freight and expressage	167 82	
	Heat, light and water	93 13	
	Chemical supplies	200 16	
	Seeds, plants and sundry supplies	311 56	
	Fertilizers	525 33	
	Feeding stuffs	447 65	
	Library	157 83	
	Tools, implements, and machinery	308 84	
	Furniture and fixtures	65 26	
	Scientific apparatus	61 76	
	Live stock	216 25	
	Traveling expenses	217 53	
	Contingent	13 25	
	Building and repairs	459 17	
			$15,000 00

WE, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Rhode Island Agricultural Experiment Station for the fiscal year ending June 30, 1895; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been fifteen thousand dollars, (see general station account in the Treasurer's hands), and the corresponding disbursements fifteen thousand dollars; for all of which proper vouchers are on file and have been by us examined and found correct.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2d, 1887.

GARDINER C. SIMS,
CHAS. J. GREENE,
Auditors.

KINGSTON, Aug. 20, 1895.

I hereby certify that the above is a true copy from the books of the account of the institution named.

MELVILLE BULL,
Treasurer of the Rhode Island College of Agriculture and Mechanic Arts.

I hereby certify that the above signature is that of the Treasurer of the Rhode Island College of Agriculture and Mechanic Arts.

C. H. COGGESHALL,
President of the Board of Managers of the Rhode Island College of Agriculture and Mechanic Arts.

MELVILLE BULL, *Treasurer, in account with the* RHODE ISLAND AGRICULTURAL EXPERIMENT STATION.

1895.	DR.	
June 30.	To balance from last year	$35 28
	Station receipts	1,346 42
	Station receipts Fertilizer inspection	2,026 57
	Interest	46 59
		$3,454 86

CR.

By Salaries	$456 62
Labor	345 16
Supplies and repairs	1,016 16
Freight and expressage, postage and stationery	27 72
Library and printing	133 25
Scientific instruments	35 70
Chemical apparatus and supplies	114 49
Live stock	5 00
Traveling	16 91
Building	128 44
Fertilizer inspection	126 88
Incidentals	26 90
Balance on hand	1,021 63
	$3,454 86

MELVILLE BULL, *Treasurer, in account with* UNITED STATES' SPECIAL APPROPRIATION.

	DR.	
1895.		
June 30.	To balance on hand	$1,581 97
	Interest	27 00
		$1,608 97

CR.

By Library	$184 28
Chemical apparatus	114 49
Scientific apparatus	35 70
Balance unexpended	1,274 50
	$1,608 97

THIS IS TO CERTIFY that the undersigned, Auditing Committee of the Board of Managers of the Rhode Island College of Agriculture and Mechanic Arts, have examined the accounts of Melville Bull, Treasurer, ending June 30, 1895, and the vouchers corresponding therewith, and find the same correct.

GARDINER C. SIMS,
HENRY L. GREENE,
CHAS. J. GREENE,
Auditors.

BULLETINS

AND

ANNUAL REPORT

OF THE

RHODE ISLAND AGRICULTURAL EXPERIMENT STATION,

FOR THE

YEAR 1895.

PROVIDENCE:
E. L. FREEMAN & SONS, STATE PRINTERS.
1896.

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OF THE

RHODE ISLAND AGRICULTURAL EXPERIMENT STATION,

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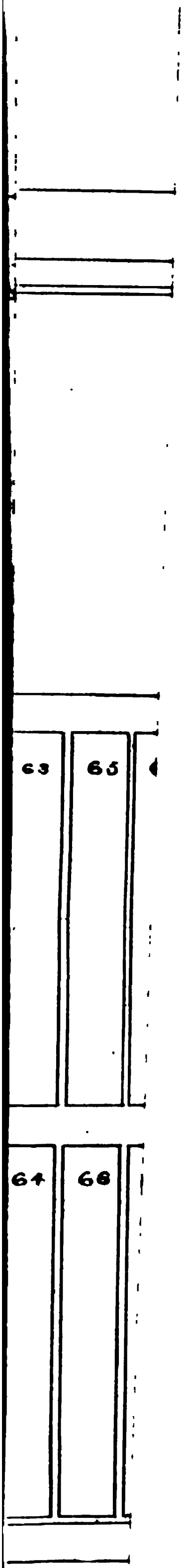

State of Rhode Island and Providence Plantations.

NINTH ANNUAL REPORT

OF THE

RHODE ISLAND

AGRICULTURAL EXPERIMENT STATION, Kingston,

1896.

PART II.

OF THE

NINTH ANNUAL REPORT

OF THE

CORPORATION, BOARD OF MANAGERS,

OF THE

Rhode Island College of Agriculture and Mechanic Arts,

MADE TO THE

GENERAL ASSEMBLY AT ITS JANUARY SESSION, 1897.

[PART I. OF THIS REPORT — COLLEGE CATALOGUE — IS PRINTED UNDER SEPARATE COVER.]

PROVIDENCE, R. I.
E. L. FREEMAN & SONS, PRINTERS TO THE STATE.
1897.

BOARD OF MANAGERS

OF THE

RHODE ISLAND

College of Agriculture and Mechanic Arts.

C. H. COGGESHALL, *President*,	Bristol, R. I., Bristol Co.
HENRY L. GREENE, *Vice-President*,	River Point, R. I., Kent Co.
CHARLES J. GREENE, *Clerk*,	Kenyon, R. I., Washington Co.
MELVILLE BULL, *Treasurer*,	Newport, R. I., Newport Co.
GARDINER C. SIMS,	Providence, R. I., Providence Co.

EXPERIMENT STATION STAFF.

JOHN H. WASHBURN, Ph.D.,	President of the College.
CHAS. O. FLAGG, B.Sc.,	Director and Agriculturist.*
L. F. KINNEY, B.Sc.,	Horticulturist.
H. J. WHEELER, Ph.D.,	Chemist.
GEORGE WILTON FIELD, Ph.D.,	Biologist.
J. D. TOWAR, B.Sc.,	General Assistant.†
GEO. M. TUCKER, B.Sc.,	Assistant Agriculturist.
BURT L. HARTWELL, B.Sc.,	First Assistant Chemist.
CHAS. L. SARGENT, B.Sc.,	Second Assistant Chemist.
GEORGE E. ADAMS, B.Sc.,	Assistant Horticulturist.
NATH'L HELME,	Meteorologist.
BERTHA E. BENTLEY,	Stenographer.

* The duties of the former Poultry Manager have been assigned to the Agriculturist.

† Five-sixth of time devoted to college work.

The publications of the station will be mailed free "to such individuals actually engaged in farming as may request the same." The station desires the co-operation of the farmers of the State in the work of investigation, and any facts concerning unusual animal or vegetable growth or disease are solicited. Visitors are always welcome. Railroad station, telegraph, express and post-office—Kingston, Rhode Island.

LETTER OF TRANSMITTAL.

To His Excellency Charles Warren Lippitt, Governor, and the Honorable the General Assembly of the State of Rhode Island, at its January Session, 1897:

KINGSTON, JANUARY 31ST.

I have the pleasure to present herewith, in compliance with the statute of the State and the Congressional act of March 2, 1887, the Report of the Director of the Rhode Island Experiment Station to John H. Washburn, President of the College, together with that portion of the Report of Hon. Melville Bull, Treasurer of the Board of Managers of the Rhode Island College of Agriculture and Mechanic Arts, which relates exclusively to the Experiment Station.

Respectfully submitted,

For the Board of Managers,

C. H. COGGESHALL,

President.

REPORT OF THE TREASURER.

Melville Bull, *Treasurer of the* **Rhode Island College of Agriculture and Mechanic Arts**, *in account with the* **Rhode Island Agricultural Experiment Station.**

United States Appropriation.

1896.	Dr.		
	To receipts from the Treasurer of the United States as per appropriation for the year ending June 30, 1896, under act of Congress approved March 2, 1887		$15,000 00
1896.	Cr.		
June 30.	By Salaries	$8,469 27	
	Labor	1,718 68	
	Publications	1,969 34	
	Postage and stationery	104 42	
	Freight and expressage	118 78	
	Heat, light, and water	99 18	
	Chemical supplies	38 88	
	Seeds, plants, and sundry supplies	548 56	
	Fertilizers	353 26	
	Feeding stuffs	26 34	
	Library	285 70	
	Tools, implements, and machinery	242 91	
	Furniture and fixtures	85 52	
	Scientific apparatus	7 25	
	Live stock	363 00	
	Traveling	334 56	
	Contingent expenses	25 79	
	Building and repairs	213 56	
			$15,000 00

WE, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Rhode Island Experiment Station for the fiscal year ending June 30th, 1896; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been fifteen thousand dollars, and the corresponding disbursements fifteen thousand dollars; for all of which proper vouchers are on file, and have been by us examined and found correct.

And we further certify that the expenditures have been solely for the purpose set forth in the act of Congress approved March 2, 1887.

Signed,

GARDINER C. SIMS,
HENRY L. GREENE,
CHAS. J. GREENE,
Auditors.

PROVIDENCE, R. I., July 15, 1896.

I hereby certify that the above is a true copy from the books of account of the institution named.

MELVILLE BULL,
Treasurer of the Rhode Island College of Agriculture and Mechanic Arts.

I hereby certify that the above signature is that of the Treasurer of the Rhode Island College of Agriculture and Mechanic Arts.

C. H. COGGESHALL,
President of the Board of Managers of the Rhode Island College of Agriculture and Mechanic Arts.

MELVILLE BULL, *Treasurer, in account with the* RHODE ISLAND AGRICULTURAL EXPERIMENT STATION.

1896.	DR.	
June 30.	To balance from last year	$1,021 63
	Station receipts	1,296 04
	Station receipts, fertilizer inspection	2,676 84
	Interest	73 17
		$5,067 68

1896.	CR.	
	By Salaries	$402 30
	Labor	846 13
	Supplies and repairs	865 49
	Freight and expressage, postage and stationery	75 70
	Library and printing	272 46
	Tools and machinery	19 72
	Scientific instruments	150 43
	Chemical apparatus and supplies	31 66
	Furniture and general fittings	87 68
	Roads, water supply, and drainage	13 93
	Live stock	142 88
	Traveling	65 21
	Incidentals	37 60
	Buildings	63 02
	Fertilizer control	839 27
	Balance on hand	1,154 20
		$5,067 68

MELVILLE BULL, *Treasurer, in account with* UNITED STATES' SPECIAL APPROPRIATION.

1896.	DR.	
June 30.	To balance on hand	$1,274 50
	Interest	51 46
		$1,325 96
	CR.	
	By Library	$169 56
	Scientific apparatus	63 06
	Balance unexpended	1,093 34
		$1,325 96

THIS IS TO CERTIFY that the undersigned, Auditing Committee of the Board of Managers of the Rhode Island College of Agriculture and Mechanic Arts, have examined the accounts of Melville Bull, Treasurer, ending June 30, 1896, and the vouchers corresponding therewith, and find the same to be correct.

GARDINER C. SIMS,
HENRY L. GREENE,
CHAS. J. GREENE,
Auditors.

REPORT OF THE DIRECTOR.

CHAS. O. FLAGG.

To J. H. Washburn, President:

In February, 1896, the Board of Managers of the College set aside for the exclusive use of the Experiment Station a certain portion of the farm, and assigned the balance of the farm lands and grounds around buildings to the use and care of the College. This change, important in its bearing upon the work of the Station, was in accord with the construction placed upon the text of the "Hatch Act" by the Secretary of Agriculture, who was instructed by the Fifty-third Congress of the United States to review the expenditures made under that act by the various States.[1]

From the organization of the Experiment Station, in 1888, and the purchase of the farm, to February, 1896, the entire farm was in charge of the Director, and maintained by the funds of the Experiment Station. It was impossible to use so large an area (139.65 acres in the original farm) for purely experimental purposes, and a large portion of it during that time was given to the growing of ordinary farm crops, while considerable areas had to be cleared from stone and brush, and other improvements made. Such use of funds derived from the United States was pronounced as foreign to the purpose of the act, which appropriated money "to promote scientific investigation and experiment respecting the principles and applications of agricultural science[2]." Large areas are seldom necessary in the demonstration of principles, and to use fields in an experiment where plots would serve the same purpose would evidently not be economical. An idea held by the general public is that the Experiment Station should conduct and maintain a "model farm," but those who think so can hardly find in the Hatch Act any authority for such an undertaking. Any thorough farmer who is a good business manager, and provided with suitable means, can conduct a "model farm" for his particular locality. The term implies that principles and methods already demonstrated as profitable be adopted, and followed with care and precision. There is nothing in the nature of investigation or experiment necessary to the successful conduct of a "model farm," and hence the legitimate work of the Experiment Station does not include the working out of that idea.

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[1] See Eighth Annual Report R. I. Experiment Station, p. 191.

[2] Bulletin No. 1, page 6, Hatch Act, Sec. 1.

In order to bring the Rhode Island Experiment Station work into harmony with the requirements of the Hatch Act, and render the schedule of expenditures acceptable to the Secretary of Agriculture, the Board of Managers found it necessary to divide the farm lands between the Experiment Station and the College, as above stated. The land set aside for the permanent use of the Experiment Station is situated on the level plain land of the farm, west of the pumping station, and south and east of the public highway at the westerly end of the farm, and includes about twenty-eight acres. The plan accompanying this report shows the location, as well as the manner in which the land is laid out for experimental purposes. A small barn, 20×40 feet in area, is situated at the north side, near the middle of the tract. This building was in a very dilapidated condition when the farm was purchased, and was so repaired as to make it useful for storage of hay and grain. Later it was moved to its present location, and a set of hay scales placed in the floorway. Being the only barn building available for the use of the Experiment Station, it has to serve for storage of all the tools, fertilizers, seeds, etc., and as a workshop in rainy weather; while the upper portion furnishes storage for a small part only of the hay produced on the experimental plots and fields. It is entirely too small for the necessities of the Station work, and additional room should soon be provided, not only for the storage of tools but to accommodate the three horses, with wagons and carts, belonging to the Station, and room for the better performance of the constantly increasing experimental work.

In addition to the land represented by the plan, the land occupied by the buildings and yards of the Poultry Division and the Apiary were temporarily assigned to the Station, and also a plot of land on the hill near the road to the Court House, for an experiment in the use of lime. Such portions of the horticultural grounds as might be required for experimental purposes, from time to time, were also assigned to Station use.

One pair of heavy horses, seven cows, ten shoats, one cart, one sled, one pair heavy team harnesses, one derrick, one grist mill and corn crusher, were sold to the College, and the balance of the neat stock was sold to private parties. The three horses retained for Station use, because of lack of room in the small barn on the plain, are boarded by the College, and kept in the College barn.

STATION STAFF.

A number of changes have been made during the year affecting the Station staff. In April, Prof. L. F. Kinney was relieved from all College duties, that his whole time might be devoted to Experiment Station work. July 1st the resignation of Mr. Samuel Cushman, as head of the Poultry Division, took effect. The appointment of Dr. A. A. Brigham as Professor of Agriculture in the College, relieved the Director from College duties at the close of the College year, in June, and the Apiary and Poultry Division work was placed in his charge, as a part of the work of the Agricultural Division, thereby consolidating the Station organization, doing away with the office of Poultry Manager, without in any degree lessening the extent of the poultry work. July 15th, Dr. George Wilton Field began his duties as Biologist at the Station, and immediately commenced investigating the conditions surrounding the growth of shell fish in Point Judith pond.

Aside from the above changes the Station organization and the duties of those constituting the Station staff remain the same as heretofore.

LIME CO-OPERATIVE EXPERIMENTS.

The numerous instances where the use of air-slacked lime has proved advantageous in experimental work on the Station farm, the results of a lime plot experiment at Westerly, together with a careful comparison of the acid conditions found in other soils, with those prevailing at the Station, led to the institution of a series of plot experiments with, and without lime, in ten different localities in the State, aside from the Station farm. These experiments are conducted with the coöperation of land owners, to whom our thanks are due for their interest in the work. Soil tests for acidity were first made, and the results of the application of lime, as thus far shown by the crops produced, confirm the value of the blue litmus paper test to the farmer who desires to profitably treat his soil. Those soils which gave the most marked acid reactions were most benefited by liming, the crops being beets, barley, clover, timothy, and red top. In some instances the beet crop has been increased over one hundred times, and a good catch of clover and grass secured by liming, where, without liming, an equal application of fertilizers, and the same treatment, has secured only the most meager crops. The reader is referred to the more extended discussion of these experiments which forms a part of this report.

FIELD AND POT EXPERIMENTS.

In addition to the Lime Coöperative Experiments mentioned above, the following field and pot experiments have been conducted jointly by the Agricultural and Chemical Divisions on the Station grounds.

Continuation of soil test with those plants which indicated, in 1894, possibly greater deficiency of potash than of phosphoric acid, but which, in 1895, have shown a greater deficiency of the latter constituent.

Observation upon the twentieth-acre plots not in the soil test, upon the relative duration of mixed grasses on limed and unlimed land.

Continuation of experiments on plots 23, 25, 27 and 29, introducing small fruits as the special feature, in connection with further observations upon grasses.

Continuation of soda-potash substitution experiment.

Continuation of experiment with gypsum and air-slacked lime.

Tests with sodium carbonate, and sodium sulfate, and some with caustic magnesia and magnesium sulfate, to study their relative action upon acid soils.

Further investigation of the potato scab with special reference to the sulfur treatment for contaminated soils.

Continuation of previous experiments with various alkalies upon acid soils with barley, in place of beets and lettuce.

AGRICULTURAL DIVISION.

Six rotations, occupying twenty-eight one-tenth-acre plots, have been continued as planned. Air-slacked lime is being used on these plots, as it has been found impossible to grow satisfactory crops of hay without liming. Care is taken, when potatoes are included in a rotation, to apply the lime to some crop following the potato crop, as rye, corn, oats or grass, because if applied just before potatoes are planted very favorable conditions are furnished for the propagation of the potato-scab fungus, and if the scab germ happens to be introduced with the seed, or exists in the ground, a badly scabbed crop might result. From one-half ton to one and one-half tons per acre have been applied with very satisfactory results.

Continuation of the comparative test of the value of phosphoric acid in nine different forms, upon limed and unlimed land. This experiment employs twenty tenth-acre plots.

Continued test of the comparative yields of various varieties of potatoes, and the relative advantage of northern and one and two year home-grown seed.

Cultural experiment with potatoes: shallow, medium and deep plowing, common and thorough cultivation, and different distances of planting sets.

Fertilizer experiment with potatoes, to test the benefit derived from increasing the per cent. of phosphoric acid.

Continuation of the oat smut experiment with Jensen hot water treatment.

Continued yields of hay, following applications of lime.

Comparison of the growth of clovers and a few other plants without nitrogen, with a small amount of nitrogen, and a large amount of nitrogen.

Continued cultivation of corn on one acre of land, using crimson clover and rye as catch crops for winter protection and fertilizing purposes.

Trial of various fodder plants and grasses.

Comparison of the yields of a yellow dent variety of corn—Leaming—with a white flint variety—R. I. White Capped corn.

HORTICULTURAL DIVISION.

Sub and surface irrigation has been tried in comparison with a non-irrigated section, the vegetable crops being spinach and celery.

A study of the habit of growth of every variety of spinach and celery obtainable, with special reference to the qualifications which make both vegetables most desirable for market.

Attention has been given to the insect enemies of garden and orchard crops, and to fungous diseases of celery and carnations.

Continuation of a garden seed investigation begun last year. This season germination tests have been made in both soil and sprouting chamber for comparison, and the sample of seed increased from two hundred to four hundred seeds in each case.

Continuation of the trial of new fruits already set out, and others which may appear from time to time.

Some observations have been made as to the adaptability of certain localities along the shore for the cultivation of the peach.

The growth of dwarf apple and peach trees in specially prepared and fertilized soils in tubs. About fifty trees of each kind have been planted.

POULTRY DIVISION.

The work in this Division was largely planned by Samuel Cushman, before his resignation took place. The plans were chiefly laid in the autumn of 1895, from necessity, considering the nature of the experiments, and the work of mating the different breeding pens, and preparing quarters for them. After July 1st the work of the Poultry Division became a part of the work of the Agricultural Division, and has since that date been in charge of the Director.

Pens of pure and cross-bred geese were exhibited at the Washington County Fair, and also at the Rhode Island Poultry Show, at Westerly, in December, at which place specimens of dressed cross-bred geese were also shown.

Unfortunately dogs broke into one of the yards where goslings were confined at night, and destroyed one entire hatch, and although the Station was reimbursed from the town dog tax fund for their market value, the loss of the data in the experimental work is deeply regretted. A larger number of goslings were raised than in any previous year, representing nearly all the breeding pens. Photographs of the various cross-breds, both alive and dressed, were secured for use, in connection with weights and other records, all of which is designed for publication in bulletin form, after one more year's work.

The work of the season may be outlined as follows:

Continuation of the goose cross-breeding experiments, involving the keeping and breeding of five different pure breeds, and sixteen pens mated for raising different crosses, the object being to obtain data for comparison of the various pure breeds among themselves as to egg production, size of eggs, fertility of eggs, and hardiness of goslings; and with the crosses, as to rapidity of growth, and general desirability for market purposes.

Incidentally, attention was given to the growing of fodder crops for geese, to be fed off on the ground, and to be cut for feeding to geese confined in pens.

BIOLOGICAL DIVISION.

The appointment of Dr. George Wilton Field as Biologist to the Station, and instructor in the College, was made by the Board of Managers, June 11th, and he began his duties July 15th. He immediately began a study of the conditions affecting the production of oysters in Point Judith pond, a body of water in the southerly part of the town, some four miles long, and from one-half to one and one-half miles wide, with a very irregular shore line, and broken by numerous islands. The Saugatucket river enters at the north end, the supply of fresh water being more or less contaminated by waste materials and dye stuffs from the manufacture of woolen goods at a point farther up the stream. At the south end connection with the ocean is at times entirely obstructed by banks of sand, thrown up by ocean waves in southerly storms. The pond, at this end, is very shallow, and the out and inflow of water, with the rise and fall of the tide, is very irregular, depending entirely upon the amount of sand thrown up by storms, which serves to block up the channel, sometimes so completely that it has to be opened by the fishermen to permit herring and other migratory fish to enter. Previous to the severe gale of September, 1869, there existed a sufficiently large "breach," or outlet, to admit of the passage, not only of large sailboats, but even sloops. Such an outlet gave comparatively free passage for the waters of the pond to flow outward at low tide, and a correspondingly free entrance to the salt water of the ocean at high tide. Fish, in considerable variety, and oysters, abounded in the pond, and were a source of profit to the fishermen. In 1869 the gale threw up immense quantities of sand, effectually choking the outlets, and cutting off the free communication from pond to ocean, which, up to that time, existed. Since that date the supply of fish and oysters derived from the pond has greatly diminished, and it was with the purpose of determining, if possible, whether any other causes than the closing of the "breach" had been instrumental in bringing about the present conditions, that Dr. Field undertook the work. Temporary quarters were secured in a small summer cottage on "Gooseberry Island," at the southerly end of the pond. With a student to assist, work was continued until the close of the season, when permission was very generously granted by Mr. Elisha F. Watson, and Hon. Arthur H. Watson, his son, for the construction of a laboratory on "Buttonwood Point," on the westerly side of the pond, considerably farther north, and consequently easier of access from the Station, and more conveniently situated in regard to the work. An appropriation for erecting the building has been made by the Board of Managers, and it will be completed for use during the summer of 1897.

Following is an outline of the investigation:

1. The cause of the death of the oysters in the pond. This

necessitates a study of the biological and chemical conditions of the pond.

2. The economic value of the pond, particularly with reference to the artificial cultivation of oysters, involving a consideration of—
   - (a) the natural set of spat,
   - (b) the prevention of the excessive precipitation of sediment,
   - (c) the amount of food in the water,
   - (d) the variation in temperature and in specific gravity of the water,
   - (e) methods of furnishing satisfactory points of attachment for the spat,
   - (f) the annual yield of the pond in its present condition.

SEED TESTING.

This work, in charge of the Horticultural Division, has been continued; only garden seeds, however, have been collected and tested. Last season only 200 seeds were taken as a sample in each case, and tests were made in cups kept in an incubating oven under conditions of comparatively uniform moisture and temperature. For the purpose of obtaining additional data, and increasing the efficiency of the work, a germination test in pans of earth was conducted in the case of each sample. Twice as many seeds were taken this year as the size of a sample for testing, which, of course, doubled the time required in counting, but added slightly to the representative value of the sample. Parallel tests were made with one hundred and fifty-one lots of seed.

FERTILIZER INSPECTION.

This work is required of the Station by a State law, and as heretofore has been conducted by the Chemical Division, the law setting aside the fertilizer license fees, received by the General Treasurer, as a fund from which to pay the expense of the inspection. The number of brands collected increases from year to year: in 1895 one hundred and twenty-five brands were secured, and this number was increased in 1896 to one hundred and fifty-one. There appears to be a desire on the part of the manufacturers of fertilizers to have it appear that *sulfate* of potash is used in a larger number of brands than is actually the case. It is quite customary to find in the printed guaranty on the bag the per cent. of potash given as "equal to......per cent. sulfate of potash." In seventy-seven cases where such a statement was found in the guaranty, examination showed that *sulfate* of potash was actually used in any considerable quantity in only *fourteen* instances. The remainder of the brands contained substantially the per cent. of potash guaranteed but in the form of *muriate*, or *low grade sulfate*, containing a high percentage of chlorine, instead of high grade sulfate.

The following table with comments from bulletin 42 (page 145) illustrates the gradual improvement in the quality of fertilizers offered for sale in this State:

	1896.	*1895.*	*1894.*	*1893.*	*1892.*	*1891.*
Equal to or above the guaranty.	90.7	89.0	80.9	75.7	80.7	71.1
Less than 0.3 per cent. below the guaranty....................	4.8	5.0	8.0	13.8	9.0	10 6
More than 0.3 per cent. below the guaranty....................	4.5	6.0	11.1	10.5	10.3	18.3

"This season, as will be observed, the goods were found equal to or above the guaranty in 90.7 per cent. of the cases. The highest record heretofore attained was that of 1895, when it was 89 per cent., while in 1891 it will be seen that this percentage was only 71. The percentage less than 0.3 per cent. below the guaranty, is lower than ever before, while the percentage *more* than 0.3 per cent. below the guaranty, which amounted in 1891 to 18 per cent., was reduced in 1895 to 6 per cent., and the past season to 4.5 per cent. Here is the most conclusive evidence that those manufacturers who do business in this State are making their goods more nearly equal to the guaranties attached to the bags in which they are sold than has been the case in any year heretofore."

It is interesting to note in this connection that those parties who have gone out of the fertilizer business in this State have been those as a rule whose goods were found to be very deficient as compared with the guaranty. It appears as one result of the fertilizer inspection, since the law placed the sampling and analysis in charge of the chemist of this Station, that the farmers of the State have every reason to feel that they get nearer what they pay for in purchasing fertilizers at the present time than ever before.

PUBLICATIONS.

A complete list of the Station publications is appended to this report for the convenience of those who wish to know the subject matter of the various bulletins and reports. Many of the earlier numbers are not now to be obtained, as the supply is exhausted, and such are marked on the list.

Seven bulletins, Nos. 36 to 42, inclusive, have been published this year, but as the numbers and titles are given in the above-named list it is unnecessary to name them here.

The demand for information relating to the subject of soil acidity and the use and influence of lime is widespread, and calls for our publications bearing upon that subject come from many points outside our own State, more especially from the older settled portions of the country. An even wider degree of interest in the poultry publications is evidenced by continued applications for numbers relating to that industry, long since exhausted and out of print.

OUR MAILING LIST.

Any person in the State interested in our work may receive our publications, free of charge, by sending their post-office address, with the request that the name be placed on the list. We would ask our readers to kindly inform us of any change of address by reason of removal from one place to another, or other cause. Postmasters are authorized by law to return our publications under our frank, free of charge, when for any reason they are not taken from the post-office,

THE SEASON.

The report of the Meteorologist forms a part of this Annual Report, and contains interesting data regarding the weather during the year.

NEEDS OF THE STATION.

As before stated, the Station is very inadequately provided with barn room, and the work of the Agricultural Division is thereby considerably hampered. A barn of sufficient size to accommodate three horses, with the necessary harnesses, team, express and other wagons, and storage for hay, would be a great convenience and relieve the rather crowded condition of the College barn by the removal of the Station horses and wagons which now have to be kept there. Time and expense would be saved in having them located nearer their work. Room would be provided for the storage of hay which now has to be stacked.

As the experimental work increases the lack of a suitable place for photographing crops, specimens of plants, etc., is more and more keenly felt. When compelled, as now, to take photographs out of doors, much time and labor is often necessary to prepare the subject so as to get satisfactory results, and even with the utmost care winds and unsuitable weather often interfere, and poor results are inevitable. A large room for the preparation of samples, and facilities for obtaining the best photographic results, would add much to the value of the field experiments, and prove economical. Considerable additional space for the storage of agricultural tools is an urgent necessity. At present all the tools owned by the Station, together with fertilizers, seeds, etc., have to be packed together into a floor space about 20 x 30 feet in area, and when any particular tool is wanted others must be drawn out until that one is reached, causing much inconvenience. Another very urgent necessity is a room for the safe storage of seeds, and also of samples of crops awaiting analysis, where they will not be injured or disturbed by vermin. A rat-proof storage room would be exceedingly valuable in our work. Facilities for photographic work, storage of tools, seeds, and experimental crops, can be provided in one building, which, together with the barn for horses, should not exceed in cost four thousand dollars. When these buildings are provided the Station could do still better work, and more economically than at present.

CORRESPONDENCE.

As heretofore, we have to report a constantly increasing amount of correspondence, which demands considerable time when given proper attention, which it is ever our purpose to do. Questions are often asked for which definite answers cannot be found, but any information available is always given, or reference made to where information may be obtained.

In closing we wish to express our appreciation of the uniform spirit of energy and good-will shown by all the members of the Station staff in their work, and in behalf of the Station to invite the reader to make a personal visit to the Experiment Station and College.

OYSTERS IN THE POINT JUDITH POND.

GEORGE WILTON FIELD.

A few generations ago the inhabitants of this region could depend upon the natural resources for food supply. They levied upon the herds of deer, the wild birds and their eggs, the indigenous fruits and grains. They "sucked the abundance of the seas," the oysters, clams, scallops and mussels; fish was a staple, supplemented by lobsters and crabs. To-day the increase in population, the improvidence of man and his wasteful prodigality, have irretrievably dissipated many of the natural resources, while others are all but extinct. Man is forced to depend upon an artificial food supply; the limits of possibilities of land cultivation are rapidly being reached. But happily by far the largest part of this world's surface is still untilled, and scientific cultivation of the water will yield comparative results far surpassing those already obtained by scientific cultivation of the land areas. The scientific agriculturist will be aided by the scientific aquiculturist; together they will solve the question of food supply for the rapidly increasing population.

Rhode Island's natural resources on land are not remarkable. Farming land of wonderful fertility, or vast mineral resources are not hers. The one feature which has been prominent since the discovery of the continent is the supply of shell-fish; but this is now surely vanishing. True, Rhode Island was foremost in recognizing the necessity of protection for this source of food and revenue for its citizens, and long ago passed beneficent laws, but more than legislation is needed. The State has a shore area which, if properly worked, as the scientific farmer tills his land, would furnish a most healthful and delicious food supply, and become one of its greatest sources of wealth. It is to the necessity of intelligent cultivation of shell-fish that attention is here directed. Immediate action alone can ensure all possible advantage. Natural beds of oysters, clams and scallops are annually becoming extinct, and with the diminished production come hardships to a worthy class of fishermen, and to the people at large an increased cost of a delicious delicacy, which should be as inexpensive as it is healthful. The cause of increasing scarcity of shell-fish is found in the fact that the natural beds, even in their pristine condition, could not supply the demand brought about by increased population, and by the development of transportational facilities, let alone the fact that many of the natural beds have been killed by man through the medium of sewage and of manufactory waste, and by persistently destructive fishing.

Let us look for a moment at some of the reasons why an animal, which annually produces from 5,000,000 to 64,000,000 eggs (a medium sized oyster lays 16,000,000), should become scarce. The American oysters are of separate sexes; the eggs and the sperm are discharged at intervals, soon after the water reaches a temperate heat; in Rhode Island waters, not many days distant from the 10th of June, when the largest number of eggs are laid. Small quantities are probably laid somewhat earlier, and even as late as September 1st. The eggs and spermatozoa float about in the water; a spermatozoon bores into the egg, and the life of the new individual, resulting from this union, begins with a series of changes too complicated to be described here. The young oyster, too small to be seen by the untrained eye, bearing no resemblance to the adult form, swims at the surface of the water for two to six days, according to the temperature (warm temperature causes a more rapid development, and hence a shorter free swimming stage), gradually acquiring the adult shape; with the formation of the shell it sinks lower and lower in the water, until it comes to rest upon some object firm enough for a support. Here it attaches itself, and becomes a tiny fixture, usually in company with thousands like itself; still, in this period of Bohemian wandering, it may have been borne miles and miles from its birthplace. It is this latter fact which has conditioned the wide distribution of the oyster. A few weeks after fixation the delicate shell is ⅛ inch in diameter; at eighteen months, 1 to 2 inches in diameter; it is then ready for transplanting, and two years later, if its lot has been cast in pleasant places, it is ready for market. It will be noticed that in the life of an oyster there are two principal crises, and one prolonged period of hazard. The first crisis is at the period of fertilization; only a small proportion of the eggs are penetrated by a sperm. The entire free swimming period is one of extreme and constant danger; a sudden fall in temperature, or a cold rain, will destroy nearly every individual, while even in propitious weather the ranks are decimated by countless enemies ranging in size from the almost microscopic copepod to the Squitteague (called, also, weak-fish, sea trout, etc.). The most dangerous period, however, comes at the time when the little embryo settles down. Comparatively few strike favorable locations, where they will be safe from accumulations of sediment, and where gentle currents will bring abundance of food. The majority drop upon muddy bottom, or upon shells or rock encrusted with slime, into which the oyster sinks, and is inevitably smothered. Prof. Möbius, the well-known German authority on the oyster, has ascertained that only one oyster in every 1,145,000 reaches maturity. But if it should escape all the dangers of early life, the oyster is pretty certain of a long and useful career, the parent of millions of offspring each year. His enemies are comparatively few, the worst being the star-fish, or "five-finger," which literally sucks the oyster from the shell; the other destructive agent is a small snail, the "drill" (*Urosalpinx*), which rasps a minute hole in the shell, through which the oyster is eaten. Other conspicuous enemies are the drum fish, skate, periwinkle, and allied forms, all except the star-fish confining their destructive attention mainly to the younger individuals. Hence it is readily seen how very important the large oysters are for perpetuating the race. The grizzled veteran of 6 or 8 inches long, protected by its limestone fortress, is will nigh invincible. But these are exactly the ones most sought by epicures, and hence by the fishermen, and as soon as the oyster has become strong enough to resist its enemies, and to furnish eggs in such numbers that, should every one hatch, and each individual mature, and produce eggs, "five years (on the supposition that no descendant of the one oyster should die) would suffice to produce a bulk of oysters whose mass would make eight worlds the size of our planet."[1] It is the capture of mature individuals by man which has been the primary cause of the depletion of our natural supply of molluscs and of fish.

To compensate for this unnatural state of affairs, it is absolutely essential to provide artificially for increasing the supply. Under cultivation the general method is to so control conditions that a larger number of young reach maturity than is usual in nature. We have seen, in the life history of the oyster, that at two periods the mortality is very great. It is at these points that artificial cultivation is most effective. Artificial fertilization may result in hatching 98 per cent. of the eggs, while furnishing, artificially, suitable objects for the attachment of the "spat," will reduce the mortality to a minimum.

The economic results of intelligent and successful oyster culture, always bountiful, are frequently marvelous. But the variations caused by local conditions are such that statistics applicable to all localities are difficult to furnish. A good natural bed, in an average favorable locality, should yield from 100 to 200 bushels of oysters per acre annually. "Twenty bushels of dead shells, planted in Upper Barnegat Bay, N. J., will become, in eighteen months, 100 bushels of seed oysters." Ingersoll, in his "Report on the oyster industry of the United States," quotes that "$13 worth of small seed oysters yielded, two years after planting, oysters which sold for $111, besides thirty bushels used as food by the farmer's family."

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[1] W. K. Brooks, American Oyster, 1891.

No section north of Dixie is so favorably situated for profitable oyster farming as the south coast of New England; and Rhode Island, in proportion to her size, is most extensively favored through the great area of shallow bays, and brackish "ponds," which indent her coast line. These warm, shallow, protected bays, are natural hot-beds, where the water is teeming with microscopic plants, which are the food of oysters, clams, scallops and mussels. Nature has endowed us with these basins for cultivating bivalves exactly similar to those for the artificial construction of which millions of dollars have been expended in France.

The shell-fish are so formed, anatomically, that practically each is an animated filter, separating from the water myriads of microscopic organisms, and using these as food. The problem before the cultivator, then, is really the continual growth of a sufficient crop of microscopic plants, and the feeding of this crop to shell-fish. We must aid Nature in this process of converting vegetable matter into animal matter. The plants grow with wonderful rapidity, and require merely the inorganic chemicals necessary for plant growth, warm, shallow, brackish water, and sunlight; practically nothing from the hand of man; the oysters need to be placed in position, secure from enemies and the engulfing mud, and Nature will do the rest.

The practicability of artifically fertilizing oyster eggs and setting free the young "spat" must be determined experimentally for various localities. It is thoroughly practicable in many cases, and I believe it can be carried out to advantage if the young can be turned into properly constructed pools until they have set.[1] (These pools may be natural or artificial.)

The method of cultivation most in vogue deals with the second crisis in the oyster's life. Assistance is rendered by furnishing an abundance of suitable material for the "spat" to fasten upon. The most generally used objects are oyster shells. The objection to them is that "spat" fixes to a shell in such numbers that growth is hindered, and by overcrowding the oysters become misshapen. Clam and scallop shells are far better for the reason that they break up at about the time when the young oyster is able to care for itself, and is not injured by dropping to the bottom. Clam and scallop shells will be found most advantageous for places not exposed to severe storms, for unless the oysters are fastened together in large masses or attached to the bottom they are liable to be thrown on shores or on flats by the waves, and there perish from freezing.

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[1] Experiments on this line have been carried on more or less successfully by J. A. Ryder, Julius Nelson and others.

Bushes, either singly or tied in bundles of convenient size for handling, though little used in this country, are found most satisfactory in France and Italy. They are particularly good for muddy bottom. This is found to be the most practicable method for collecting spat in the Point Judith Pond.

With this preface we may pass to consideration of the present condition of the Point Judith Pond. Examination shows that it is a great natural hot-bed for growing the microscopic plants which compose nine-tenths of the volume of food of oysters, clams, mussels and scallops; and that these shell-fish must thrive here just as well if not better than in the Great South Bay on Long Island, the home of the famous Blue Point oyster, if no unfavorable conditions exist. In consequence of the indubitable diminution in the yield of oysters in the Point Judith Pond, the Rhode Island Experiment Station commenced, July 20, 1896, an investigation of the causes for the decline. It is believed that the observations and experiments already begun, and to be continued during the summer and winter, with the co-operation of citizens, will bring results valuable not only to citizens of South Kingstown and of Rhode Island, but to the scientific world.

The Great Salt Pond has an estimated area of 1,500 acres of water, on the average not far from nine feet deep; a shallow pond formed during Glacial times, about four miles long from north to south, and one and a half wide at its broadest point. Its water is obtained from the Sagatucket river at the north end, from several small brooks and very numerous springs. The exit to the sea is at the south end, where the tortuous channel cuts its varying course through the shifting sands of the sea beach. This channel sometimes closes, how often I am unable to find recorded, but in 1896 it was closed from November 3 to December 10, and from December 13, 1896, to February 26, 1897. Between July 20 and November 3, the channel varied from 29 to 108 feet in width, and from 12 to 44 inches in depth. On the flood tide the sea enters through this "breach" at a maximum rate of about three miles per hour. On the ebb tide the water rapidly cuts away the sandy banks, and drops the sand off the mouth of the breach; thus is formed the sand flat which extends seaward nearly half a mile. A heavy sea casts the sand again upon the beach and chokes up the breach. If a single heavy storm or a series of storms brings in the sand faster than the pond water can carry it out, the breach tends to close, and the smaller it becomes the less likelihood is there of the pond water opening it until after several weeks a height of water accumulates in the pond sufficient to burst the barrier. The problem of a permanent breach involves caring for this great accumulation of sand off shore.

Our investigations tend to confirm the opinion of those who believe that improvements of the breach will result in the improvement of the oysters. Let us examine this question more closely. Attention has already been called to the fact that young oysters are smothered by settling upon objects even where the coating of slime is extremely thin. Sediment, either inorganic or organic, is correspondingly fatal to large oysters. If the quantity which settles is very slight, the rapid growth of the oyster enables it to keep above it; but if it settles in quantity the oysters cannot escape destruction. Freshets bring down the river considerable quantities of sediment. The current of the river is sufficient to carry the lighter part of this a long distance. My observations seem to show that most of this sediment is deposited in the area bounded by lines drawn from the Narrows to Crown Point on the north, and from Little Comfort to Gooseberry island on the south. The sediment tends to slide down into the holes, and these are filled first. A series of soundings in approximately straight lines across the pond shows that the bottom is furrowed, and that on the tops of the furrows the oysters are still living; but the mud is rapidly filling the concavities, and when it reaches to the tops of the furrows the last oyster upon the natural beds will die.[1] The history of the natural beds can be accurately read by examination of the material raked up there.

In nearly all parts of the pond oysters "set" on all suitable places —rocks, stakes, shells, sea-weed, roots of grass, etc. (Figs. 1 and 2.) So far as I have been able to observe, such oysters have flourished during the past season. It is to be expected, however, that such as are in water so shallow as to be exposed to the action of the frost will be killed. It is, however, a curious fact, and one which thus far is without adequate explanation, that the very young oysters seem to stand freezing without injury, but that after attaining the length of an inch or more the same exposure to freezing is fatal.

EXPERIMENTS TO DETERMINE WHETHER THERE ARE AT THE PRESENT TIME IN THE POND ENOUGH ADULT OYSTERS TO RESTOCK IT.

A number of bundles of twigs about 3 feet long and about 18 inches in diameter were made, and sunk just below the surface in various parts of the pond. Owing to the lateness of the season only two bunches showed young oysters, and these only a few individuals. A birch tree (fifteen feet high), however, which was put into the water early in the season, probably in May or early June, was taken up October 28th, very well covered with oysters.

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[1] I believe that the recollections of the fishermen and residents will confirm the opinion that the decline of the oyster has been most rapid in the years succeeding the closing of the "great breach," in 1869, and that this decline coincides with the much more rapid deposition of sediment during those years. With the breach closed the pond acts as a huge settling basin.

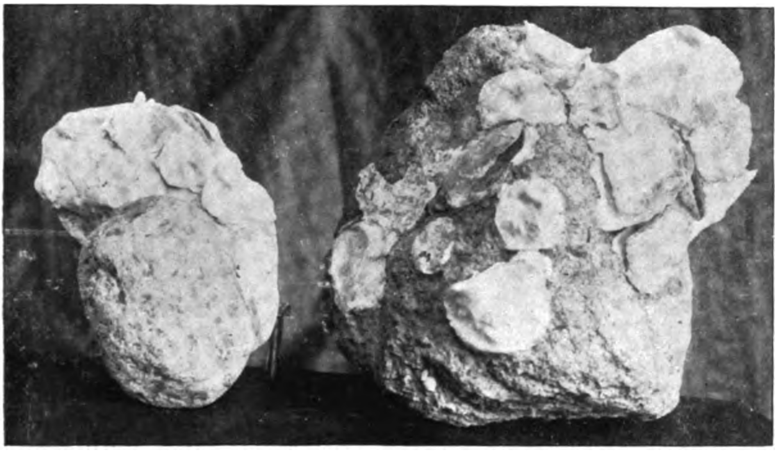

Fig. 1.

Young oysters on pebbles. Common in all sections of the pond above the surface of the mud. Demonstrates that the set of spat is abundant.

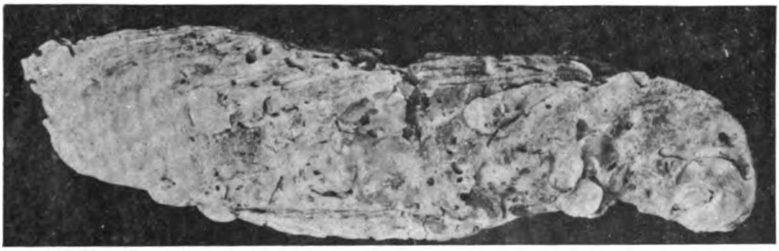

Fig. 2.

An old oyster shell from a natural bed (east of Plato's Island). Shows that some spat sets on the natural beds.

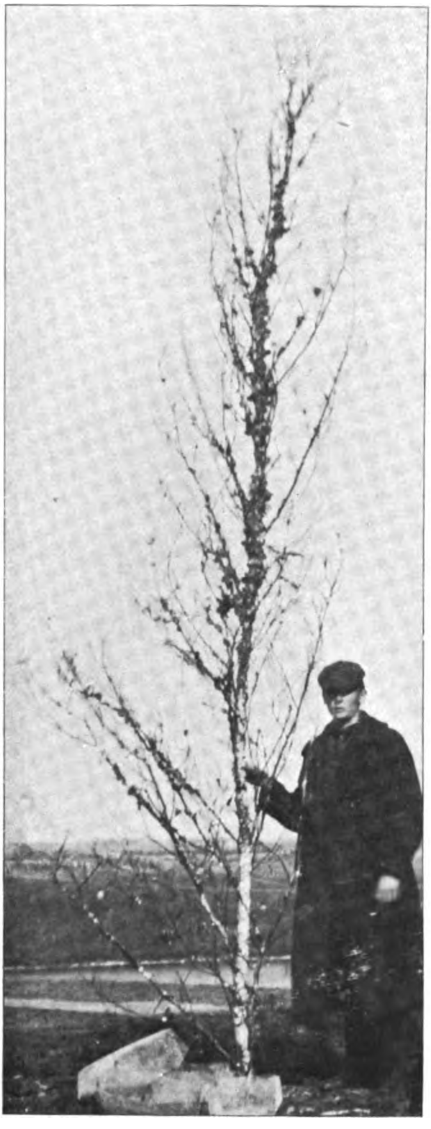

FIG. 3.

A birch tree about fifteen feet high upon which young oysters have fastened. Shows that artificial spat collecting is practicable.

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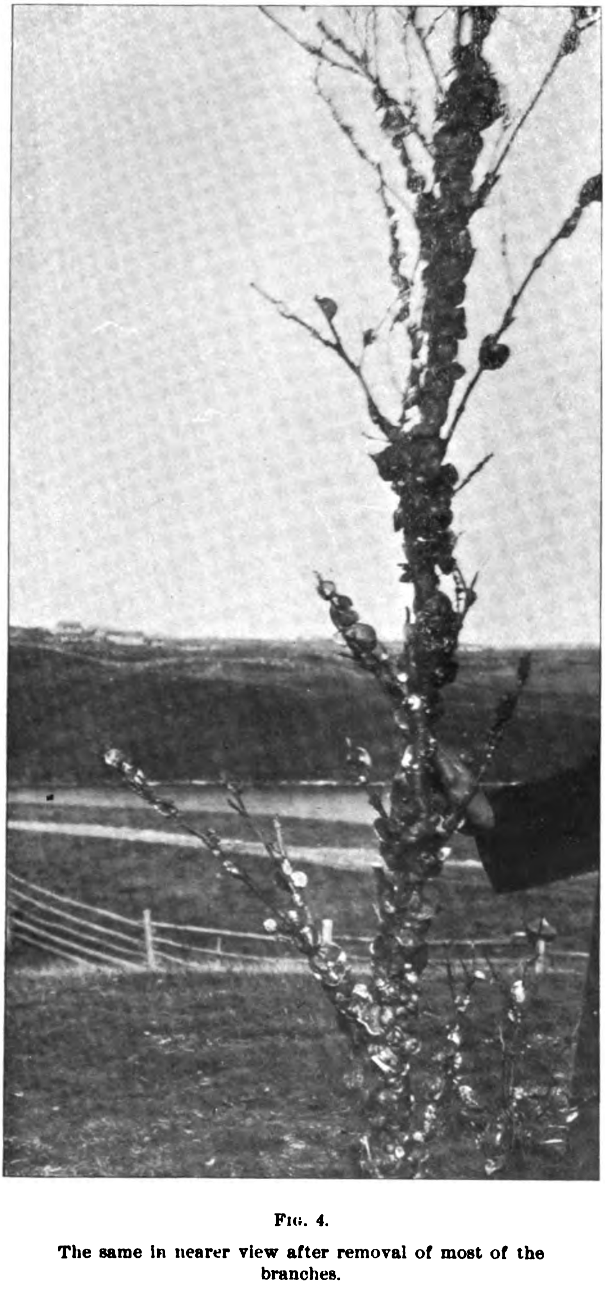

FIG. 4.

The same in nearer view after removal of most of the branches.

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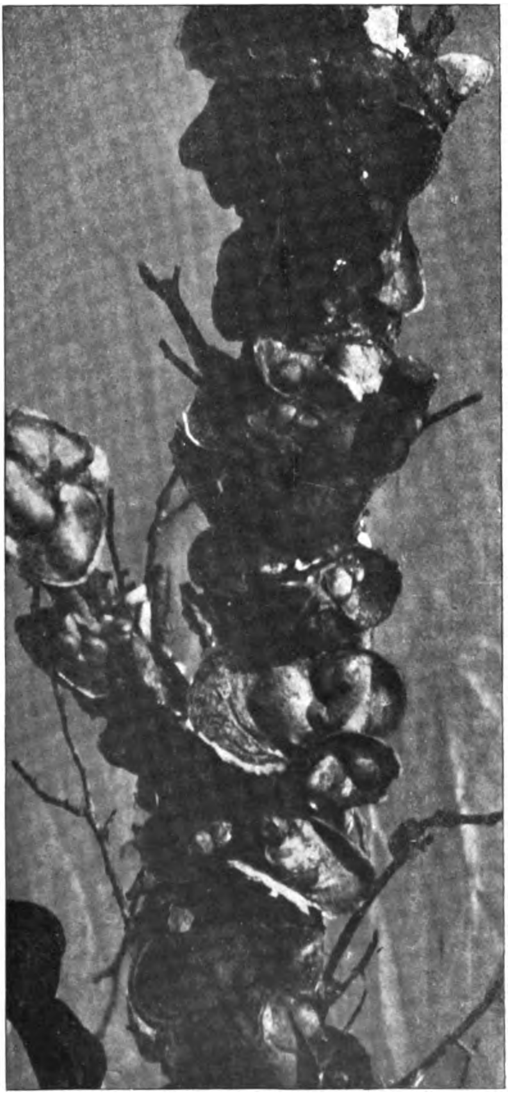

Fig. 5.

The same in still nearer view to show the individual oysters.

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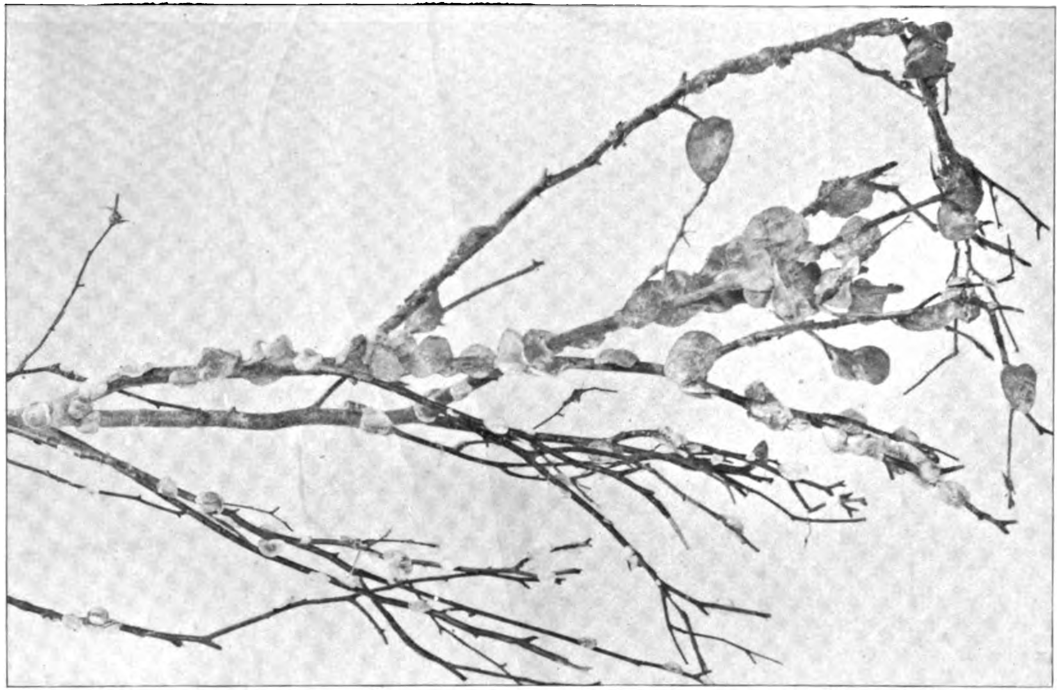

Fig. 6.

Branch showing the effect of sediment upon the oysters. As the tree settled down, through soaking and through the increasing weight of the growing oysters, the lower branches were crowded down and covered by the sediment continually deposited by the water. The oysters on the lower branches died first, as their small size indicates. The oysters on the upper twigs remained alive.

Actual count gave 2,505 (Figs. 3–4–5). After three years of favorable growth, and with a minimum of attention to prevent crowding, these should amount to at least ten bushels. This in my opinion proves that, given suitable conditions, there are oysters living in the pond sufficient to restock it, and that while there is an abundant set of spat the oysters die before attaining a marketable size, unless they fall upon the natural beds or other favorable places (which in the present condition of the pond are very limited in area).

EXPERIMENTS TO DETERMINE WHETHER OR NOT OYSTERS ARE DYING IN UNNATURAL NUMBERS AT PRESENT.

To obtain evidence upon these points, galvanized wire boxes filled with from twenty-five to two hundred oysters have been located in all sections of the pond, both on hard and soft bottom, as well as suspended on stakes at different heights above the bottom. Some of these boxes contain adult oysters 4–6 inches long; others hold sizes down to spat of last June, $\frac{1}{2}$ to $\frac{3}{4}$ of an inch long. In other cases sticks with oysters of various sizes attached have been moored in various localities. Reports from the fishermen agree as to the annually diminishing yield of oysters from the natural beds.

As to the cause of this diminution:

1. Some hold that the present extent of the pollution of the Saugatucket river from mill waste, wool scourings, and sewage is the cause.

2. Others maintain that several years ago a freshet brought down a vast quantity of refuse from the Wakefield pond which killed the oysters, and that the present scarcity is directly ascribable to that fact.

3. A third and very general view is vaguely stated as the lack of circulation of water.

In regard to the first I can only say that so far as our microscopical examination and chemical analysis can determine, we do not find that the amount and character of the contamination from these sources, though evident under the microscope, is sufficient or of a nature to cause death to oysters. The oysters in our baskets located at the mouth of the Saugatucket river, a point where the greatest effect of the contamination should be expected, have thus far shown no evidence of injury.

The whitish scum which floats upon the surface and accumulates in the bends and eddies, in the lower part of the river, consists of microscopic globules of fat, and enormous quantities of bacteria. It can be inferred that the bacteria are breaking up the oil globules by feeding upon the protoplasmic envelopes. The end results of this bacterial action are probably certain simple chemical substances, which serve as food for plants; thus, indirectly, this scum may be ultimately of value as food for fish and shell-fish. This must not be interpreted as indicating that the Saugatucket river is a legitimate, natural receptacle for sewage. Human progress has resulted in artificial conditions. Foremost among these is the question of the disposal of the accumulation of sewage, which results from the abnormal, unnatural congregation of mankind to form towns and cities, the increasing number of mills, and the waste products of manufactories. Artificial products must be disposed of by artificial methods. The proper method is to use the sewage, in suitable quantity, for the artificial cultivation of crops. Public health and public sentiment forbids that sewage should be allowed to run whither it may on land, but instances in our own State show that, after a brief period, the results of sewage emptied into a river or bay are quite as baleful as when allowed to run uncared for upon the land. We must then take heed lest, with increasing growth, the beautiful waters within the limits of South Kingstown become contaminated to such a degree that the natural vegetation in the water can no longer care for the increased quantity of foreign material. If that condition should be reached, years of time, and thousands of dollars cannot repair the injury.

In regard to the second statement (2) I have no knowledge at first hand. But the results of my observations and experiments demonstrate that the sediment which is being deposited on the beds is killing the oysters. This sediment, at the present time, comes down the river in comparatively small quantities, yet it is rapidly contracting the area where young oysters can settle, and it is daily killing the mature oysters. It would not then be surprising if an extraordinary freshet should have brought down a great quantity of debris sufficient to kill a very great number of marketable oysters, and to have covered with mud a considerable portion of the natural beds, and thus have caused a very marked contraction of the supply, a condition from which the beds have never, and can never, recover without artificial aid. It is possible, too, that as a result of this freshet, great quantities of sewage and refuse from the gas works may have found their way into the pond. But even this would have little effect in comparison with the mechanical effects of a covering of mud deposited upon, and thus smothering the oysters (Fig. 6). The gases (marsh gas, hydrogen sulfide, etc.) liberated as results of the decomposition of the mud and of the dead oysters, would, in their characteristic odors, resemble, or even be identical, with those common to gas refuse, sewage, etc. It is a well-known fact that decaying organic matter in salt or brackish water causes the formation of quantities of hydrogen sulfid, an extremely poisonous gas. The organic matter, in decaying, takes the oxygen from the sulfates, and hydrogen sulfid is liberated. Experiments will be instituted to determine the amount of hydrogen sulfid, which, dissolved in water, is fatal to oysters; and comparisons will be made with the amount found in the water of the pond.

It is under the third head, I believe, that we find the cause of the trouble; though here the difficulty is only indirectly dependent upon the circulation. The function of circulation in this case is not so much to furnish sea water in sufficient quantities as to furnish mechanically a means for preventing the deposit of mud upon that area where the natural oyster beds lie. If a free, straight, and consequently rapidly flowing outlet to the sea is furnished, a very great quantity of the mud will be carried out of the pond, instead of being deposited upon the oyster beds. Further, the inrushing tide will keep the microscopic food plants in motion, in addition to washing off and stirring up a large proportion of the sediment which may have been deposited. The fishermen assert that the oysters, at the present time, are "very thin." The reason for this is to be found in the fact that the breach has been closed, except for three days, from November 3, 1896, and is still closed at the present writing (February 26, 1897), and consequently the microscopic plants have not been distributed by the currents as usual, with the result of a scarcity of food to the oysters. Plenty of food is present in the water, on the bottom, but the oysters depend upon having their food brought to them by the currents. A further result which may be predicted with considerable certainty is that an unusual fatality will result to the oysters through the deposition of mud over all that area where the sediment drops from the river water; hence it is to be feared that the oyster beds, particularly those in the upper part of the pond, will be found now to be in bad shape, as a result of the long continued closure of the breach.

CONCLUSIONS.

As a result of our investigations and experiments we can say that we have thus far found no evidences of disease raging among the oysters, either as a result of contamination of the water by sewage or factory wastes, or from other causes.

That oysters die in great numbers in the pond is a fact. This is due in our opinion to the deposition of sediment brought down by the river. The statement of fishermen that oysters die after attaining a size of two inches or more seems to be based upon incomplete observations, the young oysters being overlooked on account of the small size, and further from the fact that as a result of special conditions an unusual quantity of mud may be deposited upon some particular bed, causing the death of a very large proportion of all the oysters on that bed. Further, since much of the sediment is deposited as a result of the spring floods, it is to be expected that the destruction involves oysters which are at least one year old. It usually happens that conditions are such that in some years most of the mud is deposited on the beds far down the pond (e. g., below the Wooded Islands), consequently for the next year the beds in that region yield practically nothing but shells. In other years the mud may settle upon the beds nearer the head of the pond. Thus we explain the fact that a bed which yields good oysters one year may disclose only "snuff-boxes" in the following spring.

It is a condition sad to contemplate that an area so valuable as the Point Judith Pond should be permitted to rapidly go to waste; in course of time, *for lack of attention*, to become a miasmatic bog-hole. The remedy is to be found in a permanent "breach," a narrow channel with a rapid current, a straight course leading from the sea to the deep water off Little Comfort Island. The sea water rushing in and out will prevent the deposition of sediment from the river water in quantities fatal to the oysters. It will insure a natural run of fish. It will permit growth of scallops, in addition to increased quantities of clams and quahaugs. At least 1,000 acres can be rendered profitable at comparatively small outlay. It is our purpose to make experimental studies of the cost of preparation per acre of bottom for oyster culture, and of the yield and consequent profit resulting from approved methods of cultivation. We hope also to report success in our attempts to introduce scallops into the pond.

So far as we can learn from our brief study of the pond, the natural endowments necessary for successful rehabilitation of the oyster industry are present: viz., an abundant food supply, optimum temperature, shelter from storms, salinity of the water, and absence of enemies. It seems necessary only to modify conditions so that the water from the Saugatucket river loaded in time of freshets with quantities of sediment, may have free passage to the sea, instead of coming to a standstill in the pond, and permitting the sediment to settle on the oysters. An incidental result will be a more rapid growth and better condition of the oysters. The waters contain abundant food, but that the food may be available to the oyster it must be moved about by gentle currents over the oysters. The food brought to the oyster must be in direct ratio to the amount of water passing over the oyster; and the quantity of food must influence the rate of growth.

It is to be hoped that means will be found to ensure a permanent breach at the Point Judith Pond, thus opening up an area whose commercial productiveness should far exceed that of any farm lands of corresponding extent in this or any other country. I do not believe that I am speaking beyond bounds in stating my belief that under proper cultivation of oysters alone the net income would pay 5 per cent. interest on more than one million dollars; to say nothing of the quantities of clams and fish; yet I cannot say that our observations are yet complete enough to warrant the expenditure of great sums of money. Our attempts at improvement are at best experimental, and the number of natural conditions are so many and so varied, that advances must be made with caution, and the results of small beginnings carefully studied.

HORTICULTURAL DIVISION.

L. F. KINNEY.

During the year three bulletins on horticultural subjects have been prepared for publication in this division, and these were issued in May, June and November respectively. The subject of the first was "Apple Culture," (15 pages and 9 illustrations); the second "The Bordeaux Mixture and its Use in the Potato Field," (10 pages and 6 illustrations); and the third "Spinach," (33 pages and 15 illustrations).

Other subjects that have received special attention are — the vitality of garden seeds; garden celery, a study of varieties and cultural methods; and acclimatization of the Loganberry. The results of these investigations are now being arranged for publication.

The rest of the work of the division that requires mention here can, for the sake of brevity, be classed under heads as follows:

USE OF FUNGICIDES AND INSECTICIDES.

Treatment of plum trees at Warwick Neck in co-operation with the owner, Mr. N. S. Allen. The results of this experiment are given further on in this report.

Copper compounds were freely used upon celery plants to prevent the blight, but at present we are of the opinion that this practice is not advisable. The disease can be controlled by other means without the slightest danger of rendering the stalks unwholesome, even if they are carelessly prepared for the table. (See Bulletin 44.)

Treatment of carnation plants at Norwood, (a) to stop the progress of the "Fairy Ring" disease and (b) the carnation rust. For results of treatment and investigation see separate article in this report.

The treatment of Bartlett pear trees at Boston Neck in co-operation with the owner, Mr. Thomas G. Hazard, to protect the fruit from injury by the curculio, although not attended with definite results was, on the whole, encouraging and will be modified and continued.

GREEN CROPS IN ORCHARDS.

A bushel of cow peas secured from Virginia was planted by Mr. O. H. J. Perry, Jr., in one of his apple orchards in Lincoln. A peck of soja beans was also planted in the same orchard. Weeds outgrew the green crops, and Mr. Perry was not favorably impressed with the result of the experiment.

In a portion of the young apple orchard at the College, crimson clover, planted in the fall of 1894, was allowed to stand in the field until it reseeded the ground before it was cut in the summer of 1895. The young clover plants came up thick and made a good growth in the fall of 1896, but a large proportion of them died out during the following winter.

Crimson clover seed from Delaware was sown in a young peach orchard last August. The plants wintered fully as well as those from home-grown seed.

CRITICAL NOTES ON VARIETIES OF FRUIT, VEGETABLES, ETC., IN THE STATION GARDEN.

Crandall currant has fruited here three seasons; plants prolific, fruit large and of better quality than that of the Missouri flowering currant.

North Star currant. Not prolific, fruit ordinary.

Pearl gooseberry. Resembles the Downing, but it appears to us to be better than that variety. One of the best gooseberries for general purposes.

Chatauqua gooseberry. Fruit very large and the plants moderately productive. A fancy fruit but slightly deficient in quality.

Marshall strawberry. About an eighth of an acre fruited here last season, and both plants and berries were unanimously admired by all who saw them; not a general purpose variety, but one unequalled in points of excellence when grown by expert cultivators of this fruit.

Margaret strawberry. A new variety sent to this Station for trial; fruit large and plants productive, but as grown here the fruit was neither larger nor better, nor the plants more productive than the standard varieties of its class now in cultivation.

Loganberry. The most promising of the several new small fruits belonging to the *Rubus* family. Bulletin 45 of this Station will contain a discussion of its cultivation in Rhode Island.

Japan wineberry. Plants of this fruit have been grown here for five years, but they have never produced berries enough to be of any value; not hardy, requires covering in winter.

Japan Mayberry. (Fig. 1.) Growth has winter-killed so badly here that no fruit has been produced.

Strawberry raspberry. As grown here entirely worthless.

Trifoliate orange. Plants badly injured during the winter of 1895 and '96, but wintered well last winter in an exposed position without protection.

Columbian raspberry.

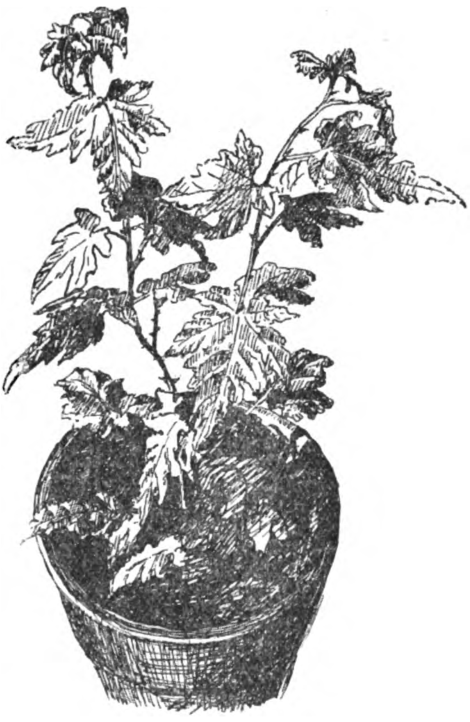

Fig. 1. The Japan Mayberry.

Canes winter-killed as badly as those of the Cuthbert; fruit of second quality; plants very prolific.

Loudon raspberry. More hardy than the Cuthbert, but the fruit as grown here not equal to that variety either in appearance or quality.

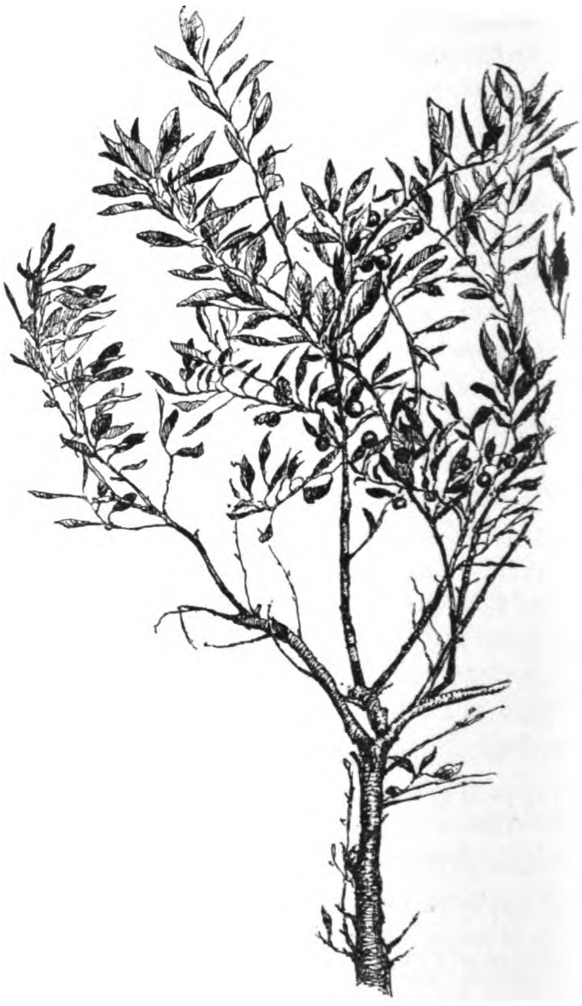

Fig. 2. Mature Dwarf Rocky Mountain Cherry Bush, 3 feet high. Lower branches cut away.

Dwarf Rocky Mountain cherry. (Fig. 2.) Bushes planted here four years ago bore their first crop of fruit last season, although they blossomed very full the preceding year. The fruit is small and black, and in our opinion not as good to eat as the wild black cherry, *Prunus serotina*, which often bears fruit in the greatest profusion when only a shrub here in southern Rhode Island, although in more favorable localities it is a tree from forty to sixty feet in height.

Royal Church raspberry. An inferior variety as grown in the

Station garden; canes neither hardy nor especially fruitful, and the berries are very ordinary in quality and crumble easily.

Crimson Rambler rose. Wintered perfectly in an exposed position without protection.

Witchuriana or Memorial rose. Perfectly hardy here last winter.

Horticultural Wax bean. A dwarf variety; productive; quality inferior.

Nott's '96 pea. An extra early wrinkled pea, both productive and of excellent quality.

Asparagus pea. To us it appears to be valuable only as a garden curiosity.

THE PLUM ROT, AND ITS EFFECT ON PLUM CULTURE IN RHODE ISLAND.

It is a thing to be regretted that the cultivation of the plum is such a precarious undertaking in this State; nevertheless the fact is too apparent to require proof. I do not know of a single plum orchard here from which the owner has received satisfactory returns, and fruit growers are generally convinced that it does not pay to attempt to grow choice varieties of plums for market, principally on account of three destructive enemies, viz.: the black knot, curculio, and the plum rot fungus.[1] It is now generally understood that the first of these, the black knot, can be controlled by cutting away the diseased parts and spraying the trees occasionally with the Bordeaux mixture to prevent reinfection; and that the second, the curculio, can also be partially controlled by spraying the trees with proper poisonous solutions several times, while the fruit is small, or more effectually by jarring the trees; but the third, the plum rot, steals in like a thief at night and devours the substance of the plums just before they are thoroughly ripe. So far this enemy of plum culture has baffled the ingenuity of plant pathologists, and it still stands in the way of the successful cultivation of this fruit. As stated in the last annual report of this Station, p. 180, an experiment in the use of fungicides as a preventive of this disease has been conducted in co-operation with Mr. N. S. Allen, of East Greenwich. Last summer the treatment in this orchard was restricted to one row containing a dozen large Spaulding trees. Fruit set very thickly on some of the trees, and they would have yielded a large crop if the plums could have been prevented from rotting. An attempt to do this by keeping the trees heavily sprayed with strong Bordeaux mixture while the fruit was green was unsuccessful. When the spray pump was stopped because the fruit was approaching maturity then the fungus improved its opportunity. It swooped down upon the ripening plums—from where we do not know—and finally nearly every fruit rotted upon the treated trees, as well as upon the others.

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[1] *Monilia.*

CONCLUSIONS.

The results of this experiment are all negative, and we find nothing to indicate that the plum rot can be controlled by spraying the trees with the Bordeaux mixture. The treatment last season was made as a final test, after considerable preliminary work had been done, and the details were carried out in a most thorough manner. It is a fact worthy of note that the fruit of different varieties of plums varies in susceptibility to injury by the rot fungus. This seems to be due, in part at least, to difference in texture of the skin of the plums, although the early varieties are usually injured more by decay than those that ripen their fruit later. Whether the Japanese varieties will prove less subject to the rot than the European, we do not know, but for the present we find encouragement in the hope that they will, and defer discussion of them until the end of the present season.

GARDEN SEEDS.

GERMINATION TESTS IN SOIL AND IN BARE EARTHEN CUPS.

L. F. KINNEY AND G. E. ADAMS.

There is no longer a doubt about the value of laboratory tests to determine the vitality of garden seed. We know that there is need of such tests, and that the results are sufficiently accurate to satisfy planters, but this is not enough; all careful workers want to have their work prove exactly. Poorly mixed samples are, no doubt, frequent sources of error, but the methods that are practiced are not yet well enough established to be entirely beyond suspicion. It is not strange that those accustomed to sowing seeds in the ordinary manner and carefully covering them with earth, are not prepared to believe that the soil is an entirely unnecessary factor in the germination of seeds, but such is the case. In fact its use is regarded as an encumbrance when seeking ideal conditions in seed testing. In its place earthen cups, blotting paper or cloth is substituted. There is no doubt, however, but what the results of germination tests that are made in soil are a little nearer like those which would occur if the seeds were planted in the garden, under favorable conditions, than those that are secured by other methods; but, after all, we cannot see that this variation has any special significance to the planter, who must make allowance enough anyway to more than cover it.

It is impossible to reduce field operations to the exactness attainable in the laboratory, so that the results of tests made by any of the approved methods show the gardener substantially the condition of his seed, which is what he wants to know. In our study of garden seeds during the past season a lot of data has been secured, which, although not obtained for the purpose, affords excellent material for making comparisons between the behavior of seeds sown in garden soil and that of duplicate samples when placed in bare earthen cups in a germinator, and as it is now a formative period for the art of testing seeds by laboratory methods in this country, a part of the data is given in the following pages.

The earth tests were made in 8 x 8 inch earthen seed pans about three inches deep. These were filled with mellow garden soil and placed on a large table in the laboratory, where the various kinds of seed were planted at about the depth that is customary in the field. The earth and germinator tests were made at the same time, and both were made in all cases in duplicate. The results given are the means between the original and duplicate samples.

Among the 151 lots of seeds of which parallel tests were made with and without earth, only 17 gave a higher percentage of germination in the soil than in the bare cups, and 12 of these were samples of beet and spinach seed. In some cases exactly the same number of sprouts were counted in both the soil and the cups, but more frequently there were from 2 to 10 per cent. less sprouts produced in the pans than in the cups. An explanation for this may perhaps be found in the fact that a few of the seeds sprouted in the cups which did not possess enough vitality to force a sprout up through the soil. As a whole the results of the soil tests averaged lower than those in the germinator, as follows:

	Number of Samples.	Average difference per cent.
Spinach	12	0.5
Beet	13	0.6
Parsnip.	12	1.3
Pepper	10	1.5
Celery	8	2.5
Cabbage	13	2.7
Carrot	11	2.9
Radish	13	3.3
Onion	10	4.4
Squash	9	6.6
Cucumber	11	6.7
Musk-melon	9	8.3
Lettuce	11	8.4
Tomato	9	12.8

From the figures given on the following pages it will be seen that the results from the earth tests, when made as described, were about as uniform as those of tests made in the bare cups, but that it amounted to marking the samples on a slightly lower scale. Our object in making the earth tests was to verify the tests made in the germinator, and we endeavored to imitate as far as possible the conditions that prevail in the field. It was not supposed that these tests would give as high a percentage of germination as those that were made in the germinator, but it was our aim to make the two series of tests under entirely different conditions, and in this way to arrive at a just estimate of the value of the seed, so far as it is determined by its vitality.

A sample of cabbage seed, No. 407, gave but 53 sprouts per hundred in the germinator, which is very low for cabbage seed, yet in the earth test only 50 sprouts per hundred were produced. A sample of parsnip seed, No. 339, produced 27 sprouts per hundred in the germinator, and only 26 in the earth test. But an examination of the tests of pepper seed shows best how the results of the two series of tests corroborated each other (see page 200), and to us this appears satisfactory proof that confidence can be safely placed in germinator seed-tests when they are properly conducted. If this is so then the results of the tests made at this Station show, *first:* that garden seed is exceedingly variable in vitality; and *second:* that there are means of determining approximately the proportion of the seed which will grow at any given time if it is planted under favorable conditions. Dealers who handle seed in bulk can furnish statements concerning the vitality of their seeds if this is required by purchasers, and it is believed that such a practice would result ultimately in an improvement in the quality of the seed offered for sale in the markets, and that this, in turn, would prove an effectual remedy for one of the common causes of unsatisfactory crops.

STATION NO.	BEET (SEED IN POD.)	Weight of 100 seeds in grams.	Per cent. of impurities by weight.	Per cent. of seed germinated at end of 4th day. Germinator.	Per cent. of seed germinated at end of 4th day. Earth.	Per cent. of seed germinated at end of 14th day. G'minator.	Per cent. of seed germinated at end of 14th day. Earth.	Number of hard seeds remaining.	One half of sample sprouted in days. Germinator.	One-half of sample sprouted in days. Earth.	NATURE OF IMPURITIES.
298	Early Eclipse	1.498	0.25	67	48	193	185	...	5	5	Inert matter.
310	Eclipse	1.72	0.75	24	2	165	160	...	7	6	Weed seeds.
322	Egyptian	1.603	0.7	103	0	162	152	....	4	6	Inert matter; particles of broken seed.
331	Eclipse	1.612	0.4	88	0	162	177	..	4	6	
343	Egyptian	1.666	1.0	59	0	170	181	....	5	5	
355	Blood Turnip	1.89	0.5	10	0	164	148	...	7	7	
372	Egyptian	1.054	4.0	15	0	129	137	....	7	7	
378	Egyptian	1.729	6.6	26	0	160	146	....	7	6	
392	Egyptian	1.582	1.0	38	0	145	150	...	5	6	
411	Egyptian	1.456	0.7	0	0	164	174	...	9	6	
416	Egyptian	1.626	1.0	55	0	119	128	...	7	8	
432	Egyptian	1.771	0.7	75	0	134	136	...	4	7	Inert matter.
439	Eclipse	1.7045	1.2	27	8	169	154	....	5	6	Inert matter.
	CABBAGE.										
299	Jersey Wakefield	0.448	0.25	82	72	84	81	....	2	4	Broken seeds.
311	Premium Flat Dutch	0.379	0.5	69	58	72	75	....	3	4	Broken seeds.
323	Flat Dutch	0.4117	0.7	88	57	90	88	....	3	4	Inert matter.
332	All Seasons	0.432	0.2	79	40	84	85	....	3	5	Inert matter.
344	Flat Dutch	0.38	0.0	90	67	93	90	...	2	4	
354	Stone Mason, Drumhead	0.3935	0.1	82	65	84	79	...	2	4	Broken seeds.
371	Flat Dutch	0.449	1.0	95	76	97	93	....	2	4	Broken seeds.
386	Premium Flat Dutch	0.4195	0.0	92	72	97	92	....	3	4	
387	Premium Flat Dutch	0.475	0.5	92	23	98	93	...	2	5	Broken seeds.
407	Flat Dutch	0.434	0.2	17	7	53	50	..	12	9	Inert matter.
415	Flat Dutch	0.434	0.5	88	79	91	90	...	2	4	Inert matter.
433	Flat Dutch	0.3815	1.8	88	65	89	83	...	2	4	Broken seeds.
414	Fottler's Early Brunswick	0.426	1.2	50	39	66	63	...	4	5	Inert matter & broken seeds.

STATION NO.	CARROT.	Weight of 100 seeds in grams.	Per cent. of impurities by weight.	Per cent. of seed germinated at end of 4th day. Germinator.	Per cent. of seed germinated at end of 4th day. Earth.	Per cent. of seed germinated at end of 14th day. Germinator.	Per cent. of seed germinated at end of 14th day. Earth.	Number of hard seeds remaining.	One-half of sample sprouted in days. Germinator.	One-half of sample sprouted in days. Earth.	NATURE OF IMPURITIES.
300	Long Orange	0.131	3.4	58	0	74	68	...	4	9	Inert matter.
312	Danver's Orange.	0.123	2.3	36	0	59	59	...	6	9	
324	Long Orange	0.1587	3.2	47	0	63	57	..	5	8	
334	Long Orange	0.1455	1.1	37	0	63	58	.	5	9	
345	Long Orange	0.11	5.7	51	0	63	67	..	4	9	Undeveloped seeds.
367	Long Orange	0.1075	5.1	49	0	62	60	..	5	9	Weed seeds.
381	Long Orange	0.14	2.9	44	0	62	58	..	5	7	Inert matter.
391	Long Orange	0.1085	5.7	50	0	62	59	..	4	9	Broken seeds.
401	Long Orange	0.1075	2.8	11	0	64	62	...	8	7	Inert matter.
414	Long Orange	0.13	7.6	31	0	62	59	..	6	8	Inert matter.
431	Half Long Danver's	0.133	9.7	9	0	32	27	..	..	..	Undeveloped & broken seeds.
	CELERY.										
301	White Plume	0.0575	0.1	0	0	37	36	...	..	..	Inert matter.
333	Boston Market.	0.0445	1.0	0	0	61	58	...	11	12	
357	White Plume	0.0585	0.8	0	0	21	20	..	.	..	
362	Giant Pascal.	0.0465	0.9	0	0	69	63	....	10	13	
385	Giant Pascal.	0.04	0.4	0	0	74	68	...	10	12	
397	Giant Pascal.	0.0575	2.1	0	0	46	44	....	..	..	
410	Golden Self Blanching.	0.03	0.3	0	0	79	76	...	10	12	
419	Giant Pascal.	0.054	0.2	0	0	83	85	.	10	10	
	CUCUMBER.										
302	White Spine	2.529	1.2	80	34	82	71	....	2	5	Inert matter.
313	White Spine	2.559	0.4	88	34	90	82	...	2	5	
325	Early Frame	2.555	0.3	79	0	82	71		2	6	

Station No.	CUCUMBER (Continued).	Weight of 100 seeds in grams.	Per cent. of impurities by weight.	Per cent. of seed germinated at end of 4th day. Germinator.	Per cent. of seed germinated at end of 4th day. Earth.	Per cent. of seed germinated at end of 14th day. Germinator.	Per cent. of seed germinated at end of 14th day. Earth.	Number of hard seeds remaining.	One-half of sample sprouted in days. Germinator.	One-half of sample sprouted in days. Earth.	Nature of Impurities.
335	Long Green..	2.796	0.9	67	10	69	64	....	2	7	Inert matter.
352	White Spine...	2.853	0.0	87	4	87	84	....	2	6	
361	Early Frame.	2.827	0.1	62	14	66	61	...	2	5	
380	Early Frame.	3.022	0.3	89	46	89	80	..	2	5	Broken seeds.
400	Early Frame..............	2.016	0.0	86	41	87	75	....	2	6	
418	Early Frame.	2.6335	0.0	71	3	76	75	..	2	6	
430	Early Russian.	2.397	0.2	71	30	72	64	....	2	5	Flesh of the cucumber.
442	Early Frame......	2.649	0.0	60	13	67	59	....	3	5	
	LETTUCE.										
303	Ferry's Early Prize Head ..	0.1587	0.7	34	62	81	72	...	8	4	Inert matter.
314	Boston Curled	0.0957	2.8	4	0	4	1	..	..	..	Foreign seeds.
336	Curled Silecia..	0.147	0.9	83	59	94	81	....	3	4	Inert matter.
346	Hanson.	0.1335	1.1	82	59	94	80	..	2	4	
358	Hanson......	0.1375	1.5	58	52	74	62	..	3	4	Foreign seeds.
369	Hanson..................	0.1375	0.6	78	49	92	81	....	2	5	Inert matter.
379	Hanson.	1.15	1.2	87	71	94	87	....	2	4	
394	Hanson......	0.136	0.5	89	96	98	96	....	2	3	
409	Hanson.	0.131	1.6	70	47	73	67	..	3	5	
417	Hanson......	0.134	5.6	87	63	90	83	....	2	4	
436	Simpson	0.156	1.0	65	57	82	73	...	3	4	
	MUSK-MELON.										
316	Green Nutmeg.	2.667	0.0	46	21	54	48	....	5	..	
337	Tip-top Nutmeg	2.927	0.0	96	7	98	89		3	7	
347	Nutmeg.......	2.564	0.0	43	0	57	51	....	5	6	

STATION NO.	MUSK-MELON (Con.).	Weight of 100 seeds in grams.	Per cent. of impurities by weight.	Per cent. of seed germinated at end of 4th day. Germinator.	Per cent. of seed germinated at end of 4th day. Earth.	Per cent. of seed germinated at end of 14th day. Germinator.	Per cent. of seed germinated at end of 14th day. Earth.	Number of hard seeds remaining.	One-half of sample sprouted in days. Germinator.	One-half of sample sprouted in days. Earth.	NATURE OF IMPURITIES.
364	Emerald Gem	2.45	0.2	41	0	48	40	....	..	..	Inert matter, small pieces of broken seed.
384	Emerald Gem	2.715	0.0	68	22	79	69	....	3	6	
396	White Japan	2.742	0.3	55	20	75	69	....	4	6	
413	Emerald Gem	2.945	0.8	82	44	84	76	...	3	5	
425	Emerald Gem	3.02	0.5	51	24	64	54	..	4	7	
443	Burpee's Golden Gem	2.845	0 0	97	48	97	85	....	2	5	
	ONION.										
315	Weathersfield Large Red	0.358	0.3	30	14	36	35	...	..	..	Inert matter.
330	Red Globe	0.354	0.0	75	49	85	82	..	2	5	
338	Yellow Globe	0.3545	0.0	61	0	82	77	....	3	6	
360	Yellow Danvers	0.395	0.2	33	0	43	40	....	..	..	
376	Yellow Danvers	0.417	0.0	64	27	77	73	....	3	6	
390	Yellow Globe	0.399	0.5	11	0	15	12	....	..	..	
405	Yellow Danvers	0.4175	0.4	80	35	93	86	...	3	5	
423	Yellow Danvers	0.371	0.0	58	47	80	78	....	3	5	
437	Yellow Danvers	0.3485	0.7	29	0	58	50	...	9	10	
445	Yellow Danvers	0.3625	0.2	42	0	57	49	....	8	..	
	PARSNIP.										
304	Hollow Crown	0.439	2.4	4	0	62	66	....	12	11	Inert matter.
329	Hollow Crown	0.482	1.66	0	0	72	67	...	8	9	
339	White Crown	0.506	0.9	0	0	27	26	..	..	..	
348	Hollow Crown	0.4335	2.1	0	0	56	61	..	12	10	
351	Long White Smooth	0.3995	1.1	0	0	48	46	..		..	
368	Hollow Crown	0.337	4.16	0	0	54	55	....	12	13	

Station No.	PARSNIP (Continued).	Weight of 100 seeds in grams.	Per cent. of impurities by weight.	Per cent. of seed germinated at end of 4th day. Germinator.	Per cent. of seed germinated at end of 4th day. Earth.	Per cent. of seed germinated at end of 14th day. Germinator.	Per cent. of seed germinated at end of 14th day. Earth.	Number of hard seeds remaining.	One - half of sample sprouted in days. Germinator.	One - half of sample sprouted in days. Earth.	Nature of Impurities.
377	Hollow Crown............	0.4675	4.76	2	0	72	65	....	8	9	Inert matter.
393	Hollow Crown............	0.441	1.7	0	0	76	76	....	9	11	
412	Hollow Crown............	0.4195	1.2	0	0	37	35	....	..	..	
422	Hollow Crown.	0.4295	1.3	0	0	60	59	...	14	10	
438	Hollow Crown............	0.3445	4.3	0	0	62	59	...	7	11	
441	Hollow Crown............	0.52	1.0	0	0	42	37	..	..	..	
	PEPPER.										
305	Bull Nose................	0.592	0.0	20	0	34	36	....	..	..	Inert matter, particles of broken seed.
317	Large Sweet Mountain....	0.6087	0.5	3	0	14	11	....	..	..	
340	Sweet Mountain...........	0.5645	1.1	5	0	30	28	....	..	..	
363	Squash................	0.682	1.4	1	0	74	71	...	11	9	
374	Squash....................	0.773	0.0	0	0	10	6	....	..	.	
399	Squash....	0.765	0.7	0	0	6	6	....	..	..	
402	Bull Nose......	0.715	0.4	4	0	37	34	....	..	..	
421	Sweet Mountain...........	0.761	1.6	7	0	69	68	...	9	11	
429	Sweet Mountain......	0.7075	1.8	0	0	38	33	....	..	..	
446	Sweet Mountain..	0.62	1.0	0	0	9	9	....	..	..	
	RADISH.										
306	French Breakfast....	0.949	1.6	81	47	85	68	...	2	5	Inert matter, particles of broken seed.
318	Early Scarlet Turnip.......	0.982	3.3	29	5	30	16	....	..	..	
328	Long Scarlet	1.315	0.5	87	63	91	76	...	2	4	
341	Scarlet Turnip.......... ...	0.9315	0.8	86	92	94	94	..	3	4	
349	Long Scarlet	1.303	0.75	66	55	84	71	....	3	4	
350	Early Long Scarlet.... ...	1.281	0.7	93	82	93	89	....	2	4	

STATION No.	RADISH (Continued).	Weight of 100 seeds in grams.	Per cent. of impurities by weight.	Per cent. of seed germinated at end of 4th day. Germinator.	Per cent. of seed germinated at end of 4th day. Earth.	Per cent. of seed germinated at end of 14th day. Germinator.	Per cent. of seed germinated at end of 14th day. Earth.	Number of hard seeds remaining.	One-half of sample sprouted in days. Germinator.	One-half of sample sprouted in days. Earth.	NATURE OF IMPURITIES.
365	Long Scarlet	1.203	3.0	70	65	85	75	....	3	4	Inert matter, particles of broken seed.
373	Long Scarlet	1.415	1.1	65	63	84	73	..	3	4	
398	Long Scarlet	1.3075	0.4	75	48	85	70	....	2	5	
403	Long Scarlet	1.2825	3.2	32	20	69	57	...	5	7	
420	Long Scarlet	1.3175	1.4	71	68	84	72	....	2	4	
434	Chartier.	1.1985	1.9	62	57	71	63	....	3	3	
448	Long Scarlet	1.2895	0.9	43	35	66	53	....	5	6	
	SPINACH.										
307	Round Summer.	0.916	0.25	1	27	39	41	....	.	..	Particles of broken seed, inert matter.
308	Prickly Winter	1.00	2.1	1	20	44	43	....	..	..	
319	Large Thick-leaved	0.852	0.2	7	2	17	15	....	..	..	
327	Long Standing	1.123	0.0	3	23	34	29	....	..	..	
350	Bloomsdale..	0.9135	0.7	19	10	42	37	...	..	..	
359	Bloomsdale..	0.965	1.46	0	11	30	28	....	..	..	
383	Bloomsdale..	0 9675	1.8	19	23	35	39	...	..	..	
395	Bloomsdale..	1.145	1.0	13	26	38	36	...	..	..	
408	Bloomsdale..	0.951	1.3	17	33	47	45	....	..	..	Weed seeds.
424	Bloomsdale..	0.964	0.9	0	11	23	26	....	..	..	Inert matter.
428	Thick-leaved.	0.999	1.5	3	4	23	25	....	..	..	
440	Bloomsdale..	0.839	1.24	9	25	41	42	....	..	..	
	SQUASH.										
326	Yellow Bush	7.682	0.0	68	0	72	67	....	3	8	Small pieces of broken seed, inert matter.
342	Bush Scallop	7.4175	0.0	85	0	86	81	....	3	7	
370	White Bush	9.115	0.8	83	0	84	84	....	3	7	

STATION NO.	SQUASH (Continued).	Weight of 100 seeds in grams.	Per cent. of impurities by weight.	Per cent. of seed germinated at end of 4th day. Germinator.	Per cent. of seed germinated at end of 4th day. Earth.	Per cent. of seed germinated at end of 14th day. Germinator.	Per cent. of seed germinated at end of 14th day. Earth.	Number of hard seeds remaining.	One-half of sample sprouted in days. Germinator.	One-half of sample sprouted in days. Earth.	NATURE OF IMPURITIES.
382	White Bush Scalloped..	6.962	0.6	27	0	40	28	....	..	..	Small pieces of broken seed, inert matter.
389	White Bush..	9.532	2.5	80	0	85	74	....	3	6	
404	White Bush..	7.532	0.0	67	0	75	62	...	4	10	
426	White Bush	8.81	0.6	29	2	36	36	....	..	..	
435	Summer Crookneck	7.175	1.15	69	0	76	65	....	3	8	
449	White Bush..	7.78	0.4	66	0	72	69	....	3	8	
	TOMATO.										
309	Acme..	0.2605	1.6	72	0	75	66	....	3	8	Flesh of the tomato and other inert matter.
320	Dwarf Champion	0.2885	0.0	68	0	92	79	....	3	7	
353	Dwarf Champion	0.2885	0.0	45	0	77	61	....	5	8	
366	Acme..	0.3335	0.2	83	0	94	82	....	3	7	
375	Acme..	0.3	0.2	92	0	95	81	....	3	7	
388	Dwarf Champion	0.2975	2.0	68	0	87	77	....	4	8	
406	Acme..	0.31	1.0	74	0	89	74	....	4	7	
427	Acme..	0.311	1.8	88	0	93	81	....	3	6	
447	Acme..	0.265	2.0	31	0	36	21	....	..	..	

THE FAIRY RING DISEASE OF CARNATIONS.

L. F. KINNEY.

Carnation pinks are grown extensively under glass in Rhode Island, and at different times various matters relating to their culture have been brought to our attention, but no actual investigations have been made until last year, when the treatment of plants having what is known as the "Fairy Ring" disease was undertaken in a house belonging to the Norwood Floral Co. When the treatment began, in the latter part of January, 1896, interest centered in a bed containing about 500 Daybreak plants that were in a bad condition, which appeared to be due to prevalence of this disease. The plants had evidently started well when placed in the bed in the fall, and had produced some flowers before they became enfeebled by the disease, but at the time of our visit only puny buds were to be seen in this bed, although on either side of it plants of other varieties were growing and blossoming freely. The peculiar spots with the

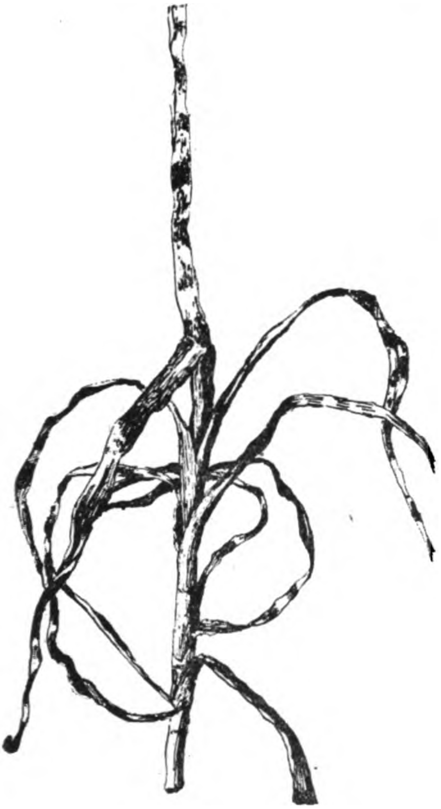

Fig. 3. Carnation Stalk with "Fairy Ring" spots upon the leaves.

characteristic rings, which suggested the name of the disease, were numerous upon the leaves and stems of the plants, and as these spots spread the plants gradually succumbed. It was evident that the disease had progressed too far on these particular plants for them to recover from its effects rapidly, but here was a good place to experiment, and we began immediately. Several fungicides were used at first, but after a few weeks all were discontinued except the Bordeaux mixture. The plants that were sprayed with this improved steadily but slowly. It enabled them to retain what vitality they had, and as new growth started it was protected from infection. The roots of the plants were in better condition than the leaves, and when fertilizers were applied they took them up as rapidly as they could be assimilated.

Our observations of these plants ceased about the middle of April, after having extended over a period of nearly three months. It was apparent that the best results had been obtained where the plants were cut back closely before the treatment began. New stocky shoots started from near the base, and some of them at the termination of the experiment had buds upon them, although the main crop of flowers on this new growth would have been too late to be of any commercial value.

The ordinary Bordeaux mixture was the most satisfactory fungicide used; the plants in some parts of the bed were sprayed heavily and frequently with it, and no injurious effects were noticed. All that was necessary to check the progress of the disease was to keep the plants constantly covered with the mixture, which we applied with a Vermorel nozzle and force pump, at intervals of from one to three weeks as the plants appeared to require it.

From the results of this experiment we infer that the Fairy Ring disease of carnations can be controlled by the use of the Bordeaux mixture.

GENERAL OBSERVATIONS RELATING TO THE FAIRY RING DISEASE.

As soon as we had demonstrated that spraying the plants with a fungicide would check the progress of this disease, the point was raised that the presence of any fungicide upon carnation blooms is objectionable. This presented another problem, viz.: How can damage from this disease be avoided without spraying the plants with a fungicide? We then began a study of the cultural condition under which carnations are grown, and during the progress of our experiment at Norwood we visited the houses of other prominent carnation growers in this State and Massachusetts, and viewed no less than 200,000 flowering carnation plants. The Fairy Ring disease was known by name to only a small proportion of the growers in whose houses we found it. In a few cases the gardeners were picking off the lower leaves and "cleaning up" their plants, but generally the disease was not doing serious damage. An inquiry concerning the source from which the young plants were obtained developed a line of evidence which, when followed up, showed that the Fairy Ring had been introduced into the various houses in this State mainly from a common center, where it had become established and was disseminated with the cuttings that were sent out; but, as already stated, it seemed to thrive only under exceptional conditions, and these conditions were not such as are considered the most favorable for the growth of carnations. It seemed to be intimately associated with the Daybreak, and where it occurred in houses containing these plants it could usually be found upon them—although several thousand plants of this variety were examined which showed no trace of it. Probably no variety of the carnation is exempt from this disease. We have seen it on a large collection of seedlings, and upon standard varieties, but we conclude that the Scott, and some other varieties that possess unusual vigor, are not injured by it under ordinary conditions, even if diseased plants of other varieties grow among them. The Daybreak plants were also able to outgrow the injuries caused by the disease when in light and airy positions, but when planted closely in deep beds, where the surface soil and lower leaves remained moist a good deal of the time during the winter months, the disease when once established spread rapidly, and the plants gradually succumbed to it. The bed of Daybreaks at Norwood, where our attention was first called to the disease, was in such a position. It was situated between two other beds, but its location was less favorable than either of them, although this fact was brought out only after a large number of other cases had been considered.

To start with, the disease was probably present on the lower leaves of the plants of this particular variety when they were put into the bed in the fall, and the position in which they were placed happened to be more favorable for the development of the disease than for vigorous growth of the plants; that is, there was a deficiency of light, and but little circulation of air. As a result of these conditions there was a dampness in which the disease-producing fungus flourished to such an extent that it overrun the plants; but in other places, where the conditions were relatively more favorable for the plants and less favorable for the fungus, we found the injury from this disease varying from almost entire destruction of the plants to none at all. We therefore conclude that strong light, fresh air, and a moderate amount of moisture, when properly combined, make the *best* fungicide to use in the treatment of the Fairy Ring disease of the carnation. If, however, this cannot readily be secured, the Bordeaux mixture will answer as a last resort, even when the plants are in bloom, and it can probably be used to a good advantage upon young stock that is propagated from diseased plants. Even if the Fairy Ring of the carnation is a comparatively new disease in this country, as has been asserted, it is now generally disseminated, and will doubtless continue to cause carnation growers more or less trouble, according to the care that is observed in avoiding injuries from it. If it is necessary to treat the plants at all this should be done in the summer, that they may have a good health certificate when they pass into the houses in the fall, for there is no doubt but what the disease is contagious.

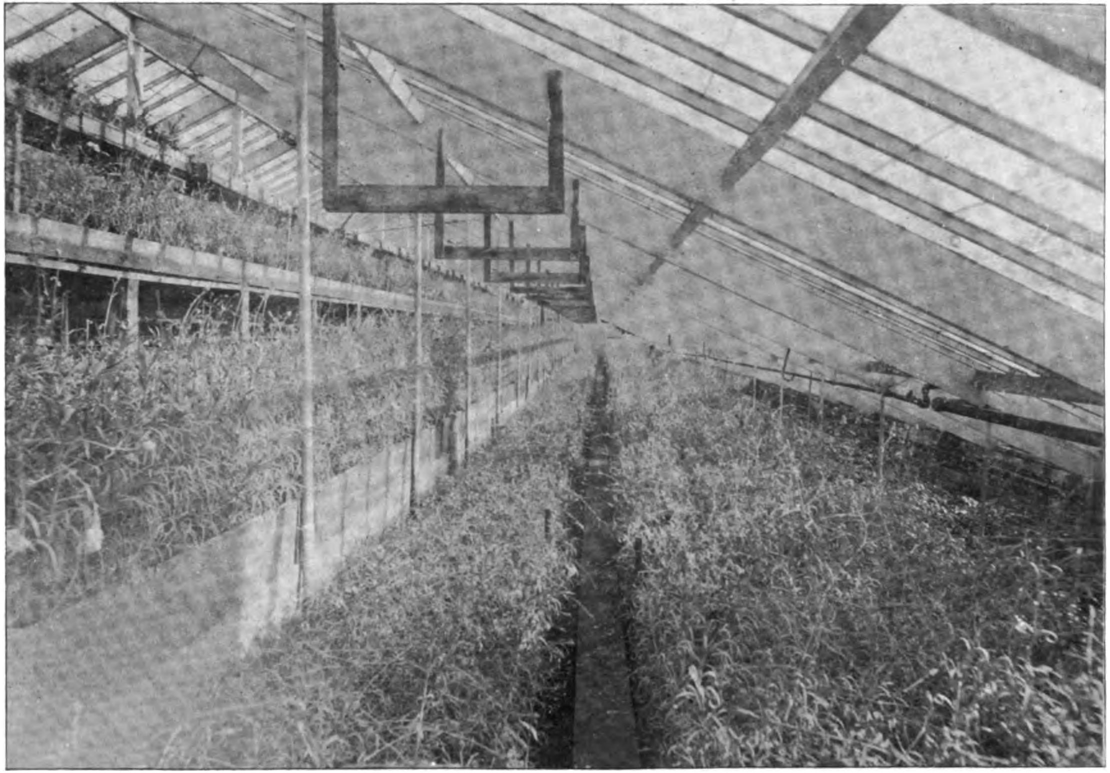

Fig. 4. View in greenhouse, at Norwood, showing the bed of Daybreak plants attacked by the Fairy Ring disease on the left of the plank walk in the centre of the picture. The plants on the right of the plank were seedlings, and considerably injured by the disease, but the Scott plants in the raised bed back of the Daybreak, and the McGowan plants in the shallow bed still higher, were not noticeably affected by it.

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THE CARNATION RUST.

L. F. KINNEY.

This is now looked upon by carnation growers as an old offender, and a real parasite on their business. It occasionally re-appears in all houses unless the most rigid measures are enforced to keep it out, and when once inside the doors, if trifled with, it has a way of making itself very much at home, and often becomes an intolerable nuisance. Of course the best way to deal with this disease is to effectually exterminate every trace of it as often as it is discovered, even if it requires the sacrifice of some plants; but for various reasons it is often treated leniently until too late, when even the control of it becomes a serious matter. While experimenting with the Bordeaux mixture as a remedy for the Fairy Ring disease, at Norwood, we also made experiments with it upon plants having the rust. It was used on sections of a bed of McGowan, where the plants were in bloom, with decidedly beneficial results. The plants began to improve immediately, and they blossomed more freely where they were sprayed than where they were not, but there was no indication that spraying these plants with the mixture would completely cure them of the disease. It simply impeded its progress until the plants were able to produce their crop of blooms, when they would be dug out and destroyed. But here, as in the preceding case, the blooms picked from the treated plants were unsaleable on account of traces of the mixture that adhered to the stems. This treatment is to be used therefore on flowering plants only as a last resort, although, so far as checking the progress of the disease is concerned, probably the Bordeaux mixture is more effectual than any of the other fungicides in use.

The treatment of the plants referred to consisted simply in spraying them, at irregular intervals, for nearly three months, in mid-winter, with the ordinary Bordeaux mixture.

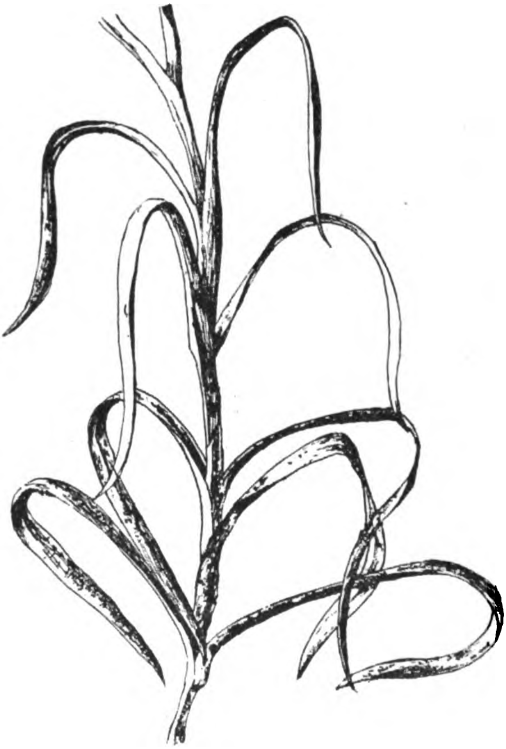

Fig. 5. Carnation Stalk with rusty leaves.

In another place a similar experiment was made in the treatment of a lot of rooted cuttings of the Daybreak carnation that a gentleman had purchased. Although he had been assured that they were propagated from healthy stock, before they had been in his house a week nearly every plant was broken out with the rust. Here the Bordeaux mixture could be used freely as there were no blooms in the way, and the results were very satisfactory. The treatment was begun early in February 1896, and extended over a period of about three months. By the first of March the cuttings had made considerable new growth, and on March 2d all leaves with rust upon them were picked from 400 plants—one-half of these plants had been sprayed twice and the remainder had not been treated. The effect of the treatment was shown at this time in the smaller number of diseased leaves that were found upon the plants which had been sprayed; the total number picked from these at this time being 1,164, while from the 200 plants that had not been sprayed, 1,434 diseased leaves were picked. After this both the treated and the untreated plants were free from rust spots. Another application of the Bordeaux mixture was then made to those plants that had been sprayed before. On March 21st, nearly three weeks later, the young plants were again examined, and all leaves having rust spots upon them were picked off. This time there were only 26 on the 200 treated plants, and 166 on those that had not been treated. There seems to be little doubt but what plants of this kind can be actually cured of the rust by persistent use of the Bordeaux mixture, and we know of no other equally effective remedy for this disease when it appears upon young stock. It should be understood, however, that it is a slow process to exterminate this disease, and that the work should not rest as long as a trace of it can be found. Even after the plants appear to be free from it they should be carefully watched, to discover any rust spots that may have been overlooked or that break out later. In case any are found the diseased portion of the plants should be promptly removed and effectually destroyed, and the use of the Bordeaux mixture continued a few weeks longer.

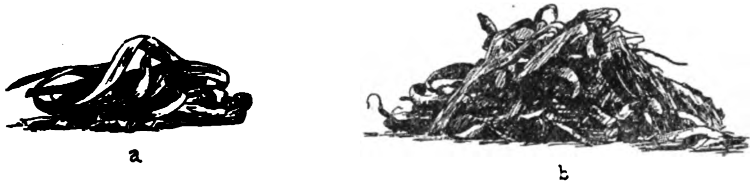

Fig. 6. Rusty Carnation Leaves picked March 21.

(*a*) *From plants sprayed with Bordeaux mixture.* (*b*) *From plants not sprayed.*

The Rust and Fairy Ring are the most troublesome diseases of carnation plants as they are now grown in Rhode Island. There is, however, another matter to which our attention has been called that has an important bearing upon carnation culture. To us it appears to be a deformity rather than a disease in the ordinary sense that this word is used. Among growers it is known as the production of "petrified" buds. In all of the cases that we have seen the plants have been more than ordinarily vigorous, and the buds were produced freely, but they did not open. They would remain hard for a week and then dry up. Whole beds of plants sometimes only produce this kind of buds for months. At present it is believed to be due to careless preparation of the soil. It is supposed that the use of strong fertilizers, which cause an excessive leaf growth, are responsible for it, and there seems to be considerable evidence that this is the case, although we are not yet certain that this is the sole cause. We have seen more "petrified" buds upon Scott plants than upon those of any other variety, yet it is not simply a peculiarity of this variety. If the trouble is due to forcing the plants excessively, as at present appears to be the case, then it can be easily avoided, and the fact that there has been much less complaint about it during the winter of 1897 than there was during that of 1896, indicates that proper care in the use of fertilizers is all that is necessary to guard against it. If this premise is verified by further observations, with proper management of carnation plants no serious damage need be anticipated either from this trouble, the Fairy Ring or the Rust.

CHEMICAL DIVISION.

H. J. WHEELER.

The work of the chemical division having been, as usual, more or less varied in character, it will be described topically, as in previous reports.

FERTILIZER INSPECTION.

As usual the collection and analysis of fertilizing materials sold within the State have been conducted by this division in accordance with the law regulating the same. In 1891 but fifty samples were collected and analyzed, subsequently the number exceeded one hundred, and in 1895 it amounted to one hundred and twenty-five. In 1896 the total number of samples has amounted to one hundred and fifty-one, divided as follows: Complete Fertilizers, 113; Nitrate of Soda, 4; Muriate of Potash, 4; Acidulated Bone, 2; Ground Bone, 3; Tankage, 3; Sulfate of Potash, 3; Kainit, 1: Dissolved Boneblack, 2; Dried Blood, 1; Wood Ashes, 10.

These analyses have been published in Station Bulletins Nos. 39, 40 and 42, and have been compiled in another form for publication in the Annual Report of the State Board of Agriculture, in connection with a brief review of the fertilizer inspection for the past six years.

METHODS OF ANALYSIS.

In connection with the work on methods of analysis conducted by the Association of Official Agricultural Chemists, a few determinations were made, and the results forwarded to the reporters of the Association for embodiment in the proceedings of the Association.

SPECIAL CHEMICAL INVESTIGATIONS.

The investigations previously begun, for the purpose of determining, if possible, the relative acidity of soils, have been continued whenever opportunity afforded.

More or less work has likewise been done for the purpose of determining the effect of liming upon the percentage of humus and of humous nitrogen in soils. Determinations of lime and "free humic acid" have been made in a number of soils, from various parts of the State, in connection with actual tests of the effect of air-slacked lime upon the growth of beets and barley, which crops are to be followed by grass and clover. It is hoped by some chemical means, perhaps combined with a physical examination, to be able to prescribe more definitely the amounts of lime which should be used on acid soils, than would be possible simply from a test with blue litmus paper. The results of these soil investigations will be published later in special articles.

FIELD AND POT EXPERIMENTS.

In addition to the field and pot experiments undertaken in 1895 in co-operation with the Agricultural Division, a number of systematic trials of air-slacked lime have been made in connection with barley and beets, for the purpose of ascertaining if deficiencies of lime in form of calcium carbonate are more or less general throughout the State. The data secured in this experiment, as well as those secured in connection with the pot and field experiments, have been prepared for publication with the assistance of Mr. G. M. Tucker, and are to be found in Bulletin 40, and in this Report. A more detailed enumeration of these experiments may be found in the report of the Director on page 162.

CORRESPONDENCE AND PUBLICATIONS.

The amount of correspondence has steadily increased from year to year, the total amount of which occupies considerable time.

The publications for the year, aside from the articles in this Report, are the following:

Bulletin No. 39, July. "Analyses of Commercial Fertilizers," 8 pp., by H. J. Wheeler, B. L. Hartwell and C. L. Sargent.

Bulletin No. 40, October. "Fertilizers," 9 pp., by H. J. Wheeler, B. L. Hartwell and C. L. Sargent; "Potato Scab," 19 pp., by H. J. Wheeler and G. M. Tucker.

Bulletin No. 42, December. "Fertilizers," 17 pp., by H. J. Wheeler, B. L. Hartwell and C. L. Sargent.

In addition to the above, a paper on "The Recognition of the Acidity of Upland Soils as an Indication of their Need of Calcium Carbonate," was prepared and read by me at the Convention of Agricultural Colleges and Experiment Stations, held in Washington, D. C., in November.

INCREASED LABORATORY FACILITIES.

Attention has been called annually, for several years, to the fact that the wing of the "Laboratory Building" assigned for use as a chemical laboratory does not offer proper facilities for either the economical or the most satisfactory execution of the work demanded of the division. The other wing of the building, originally intended for the use of the Experiment Station, has been occupied up to the present time by the College, for which it is also inadequate. It is therefore earnestly to be hoped that proper facilities may be provided for the College in another building, so that the other wing of the laboratory building may be utilized for the chemical work of the Station.

ACKNOWLEDGMENTS.

To my assistants, Messrs. Hartwell and Sargent, is due very much credit for their close attention to the work of the division, and for the great interest shown in everything which has been undertaken. In proof reading, tabulating results, and in many other ways, Mr. Hartwell particularly has rendered additional assistance. I am indebted likewise to Mr. G. M. Tucker for his active interest, and for the care taken in connection with the experiments conducted in co-operation with the Agricultural Division, and to Mr. G. E. Adams for his painstaking photographic work in connection with the same.

MISCELLANEOUS ANALYSES NOT PUBLISHED ELSEWHERE.

242. Wood Ashes, from A. E. Whitford, Exeter.
243. " " " W. E. Hopkins, No. Scituate.

	242.	243.
	Per cent.	Per cent.
Water	5.88	*
Phosphoric acid	3.16	*
Potash	4.90	6.36

244. Slag Meal, for the Station.
245. Dissolved Boneblack, for the Station.
246. Dissolved S. C. Rock, for the Station.
247. Double Superphosphate, for the Station.

	244.	245.	246.	247.
	Per cent.	Per cent.	Per cent.	Per cent.
Soluble phosphoric acid	*	13.43	11.80	41.58
Reverted " "	*	2.12	1.02	6.40
Available " "	4.65	15.55	12.82	47.98
Insoluble " "	13.75	.35	1.19	1.23
Total " "	18.40	15.90	14.01	49.21

248. Raw Alumina Phosphate, for the Station.
249. Floats (fine ground), " " "

	248.	249.
	Per cent.	Per cent.
Water	14.82	*
Phosphoric acid	35.43	26.11

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* Not determined.

250. Ground Bone and Meat, from W. H. Tabor, Slatersville.
251. Coarse Bone, from Henry Hedly, Portsmouth.
252. Tankage, for the Station.
253. Fine Ground Bone, for the Station.

	250. Per cent.	*251.* Per cent.	*252.* Per cent.	*253.* Per cent.
Water	4.06	*	*	*
Nitrogen	7.13	3.63	5.68	2.34
Phosphoric acid	9.75	23.01	14.60	27.43

MECHANICAL ANALYSIS OF NO. 253.

Medium	10.48
Fine Medium	23.14
Fine	66.38

254. Refuse from Soap Works, from Geo. Birchell, Lonsdale.
255. Dissolved Bone, for the Station.

	254. Per cent.	*255.* Per cent.
Nitrogen	1.89	3.11
Soluble phosphoric acid	*	2.70
Reverted " "	*	12.22
Available " "	*	14.92
Insoluble " "	*	4.91
Total " "	0.11	19.83
Potash	0.18	*

Estimating nitrogen at 15½, phosphoric acid at 5½, and potash at 4½ cents per pound respectively, the commercial value of No. 254 would be $6.14.

256. Dried Blood, for the Station.
257. Sulfate of Ammonia, for the Station.
258. Nitrate of Soda, for the Station.

	256. Per cent.	*257.* Per cent.	*258.* Per cent.
Water	*	*	2.70
Nitrogen	11.88	20 55	15.62

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* Not determined.

259. Soda Ash, (sodium carbonate), for the Station.
260. Common Salt (sodium chlorid), " " "

	259. Per cent.	*260.* Per cent.
Water	*	4.55
Soda (sodium oxid)	56.46	49.49

No. 260 contained likewise small quantities of sulfates and chlorids of lime and magnesia, the amounts of which were not determined.

261. Potassium Nitrate, for the Station.
262. Potassium Carbonate, " " "
263. Muriate of Potash, " " "
264. Sulfate of Potash, " " "

	261. Per cent.	*262.* Per cent.	*263.* Per cent.	*264.* Per cent.
Potash (potassium oxid)	46.49	58.20	52.56	52.08
Nitrogen	13.87	..	..	..

265. Peruvian Guano, (I), J. A. Budlong & Son, Auburn.
266. Peruvian Guano, (II), J. A. Budlong & Son, Auburn.

	265. Per cent.	*266.* Per cent.
Water	7.07	11.31
Nitrogen in nitrates	.59	1.70
" " ammonium salts	7.28	5.58
" " organic matter	.38	.88
Total nitrogen	8.25	8.16
Soluble phosphoric acid	.51	.74
Reverted " "	4.05	5.22
Available " "	4.56	5.96
Insoluble " "	5.88	4.44
Total " "	10.44	10.40
Potash	1.27	1.57
Chlorin	1.20	1.48
Commercial valuation (prices for 1895)	$38.52	$38.44

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* Not determined.

Peruvian guano, such as was formerly offered for sale in this country, is practically exhausted; these materials, like most others offered for sale under this name, had unquestionably received generous additions of ammonium salts. In fact material of equal manurial value might be prepared by any one by the employment of commercial phosphates, sulfate of ammonia, nitrate of soda, and muriate or sulfate of potash.

267. Wool Waste, from John Maglone, Bellville.

	267. Per cent.
Water	2.65
Phosphoric acid	.26
Potash	2.41
Nitrogen	1.16

268. Epsom Salts (magnesium sulfate), for the Station.

	268. Per cent.
Magnesia (magnesium oxid)	16.06

The following analyses of mangel wurzels and sugar beets have been made, for the purpose of noting if any particular change in their percentage of sugar had resulted as a consequence of the employment of air-slacked lime. The mangel wurzels were such as are ordinarily grown for fodder purposes. Both kinds of sugar beets (Zuckerreicher and Ertragsreicher) were grown from seed sent for trial by C. H. Dietz, of New York, which was said to have been raised upon the farms of the Emperor of Austria.

		Per cent. Sugar.[1]
No. *269.*	Mangel Wurzels grown on plot 25	1.65
No. *270.*	" " " " " 27	3.36
No. *271.*	" " " " " 29	2.55

Plots 25 and 29 had been previously treated with air-slacked lime, while 27 had not. Each plot had received the same amount of dissolved boneblack and muriate of potash for several successive years. In 1895 and 1896 each had received, in addition, like amounts of magnesium sulfate in the form of Epsom salts. Each plot had likewise received for several years like quantities of nitrogen, that on plot 25 having been applied in the form of sulfate of ammonia, and that on plots 27 and 29 in the form of nitrate of soda. No analyses of beets are reported from plot 23, which corresponded exactly with plot 25, except that it was unlimed. In the case of this plot, though the seed germinated, the plants, with rarely an exception, died within a few weeks, and the few which survived failed to produce a sufficient amount of root for analysis.

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[1] The sugar was extracted by means of alcohol in a Soxhlet extraction apparatus, and the amount determined by polarization.

The sugar beets examined were grown upon sections of plot 36, upon the Experiment Station farm. Sections 1 and 2 received in 1894 two-thirds of their potash in the form of muriate and one-third in the form of sulfate, while sections 7 and 8 received one-third as muriate and two-thirds as sulfate. Sections 1 and 7 received air-slacked lime at the rate of 2½ tons per acre, while Nos. 2 and 8 remained unlimed. So far as concerned nitrogen and phosphoric acid, they were all treated alike. Since 1894 all of the sections of the plot have received the same manurial treatment.

NO. OF ANALYSIS.	NO. OF SECTION.	KIND OF BEETS.	Water. Per cent.	Sugar.[1] Per cent.	Purity Co-efficient.	Numerical Value.
272.	1. Limed. ..	"Ertragsreicher."	85.73	10.01	70.15	702.0
273.	2. Unlimed.	"Ertragsreicher."	88.27	8.25	72.63	619.0
274.	7 Limed. ..	"Zuckerreicher."	87.06	9.82	75.88	745.0
275.	8. Unlimed.	"Zuckerreicher."	84.80	10.67	70.19	749.0

The numerical value given above is obtained by multiplying the percentage of sugar by the purity co-efficient. Other things being equal the beets showing the highest purity co-efficient are the most valuable for sugar making. Since this factor as well as the percentage of sugar must enter into consideration, the numerical value as obtained above furnishes a probable index of the relative value of different lots of beets.[1] The data given, which were all that were obtainable the past season, are contradictory, and even if they were not so would be insufficient to be fully conclusive as to the effect of liming upon the percentage of sugar in beets grown under our Rhode Island conditions. It may be desirable to further investigate this question in coming seasons, yet there is little probability that further, or at least immediate attempts to manufacture sugar will be made in this section. At all events, the experiments with lime thus far conducted show conclusively that Rhode Island soil cannot be made to produce maximum crops of beets until liming is resorted to. It seems probable likewise that many of the failures in beet culture which were met with by those who attempted to grow them for the beet sugar factory which was established at Franklin, Mass., several years ago, were attributable to a deficiency of carbonate of lime in our soils.

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[1] The sugar was extracted by means of alcohol in a Soxhlet extraction apparatus, and the amount determined by polarization.

276. Leggett's "Fungiroid," sent by John Butterworth, Warren, R. I.

	276 Per cent.
Copper oxid (CuO)	11 84
Lime (CaO)	38.70
Sulfuric acid (SO_3)	13.29

This material also contained water, magnesia, carbonic acid, etc., and resembled a dry Bordeaux mixture. The magnesia is readily accounted for from the fact that it is present to a greater or less extent in most burned lime, which is an important ingredient of the Bordeaux mixture.

Analyses 277 to 286 were analyses of water of the Great Salt Pond, South Kingstown, R. I., which were made for Prof. Field, of the Biological Division of the Station, in connection with experiments in oyster culture, and will be published by him in connection with a description of that work.

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[1] Stohmann, Zuckerfabrikation, Berlin, 1885, p. 39.

ANALYSES OF WATER SENT FOR EXAMINATION.

(PARTS PER MILLION).

NUMBER.	PARTY SENDING, AND LOCALITY.	DATE OF ANALYSIS.	FREE AMMONIA.	ALBUMINOID AMMONIA.	CHLORIN.	REMARKS.
277	Boyd Bros .... Portsmouth..	Jan. 29.	.06	.09	17.0	Fair. Nitrogen as nitrates 2.7 parts per million.
278	Mrs. G. P. Kenyon....Wood River..	Apr. 25.	.03	.14	17.0	Somewhat contaminated. Much sediment, consisting chiefly of hydrated ferric oxid.
279	Mr. Sherman... . ....Matunuc....	Aug. 7.	.07	.25	72.0	Badly contaminated, as shown by the large amount of ammonia. Owing to the proximity to the ocean the chlorin does not necessarily indicate contamination.
280	Geo. M. Tucker...... Kingston....	Sept. 30.	.11	.08	23.0	Considerably contaminated.
281	Mrs. E. Bosworth .. .Kingston ..	Oct. 8.	.09	.09	32.0	Considerably contaminated.

ON THE SUBSTITUTION OF SODA FOR, AND ITS VALUE IN CONNECTION WITH, POTASH.

H. J. WHEELER AND G. M. TUCKER.

The experiments to be enumerated in this article are a continuation of those described in the Seventh Annual Report of this Station, for 1894, pp. 168–182, and in the Eighth Annual Report, for 1895, pp. 215–231. It is unnecessary in this place to enter into a discussion of previous work in this line, and of the data and opinions of others in relation to the same, for these points have been more or less thoroughly considered in the two preceding articles on this subject. In 1894 and 1895 an abundant application of nitrogen, in the form of dried blood, was made to each of the 48 plots involved in this experiment. An abundant supply of phosphoric acid in various forms was likewise furnished during each of those years. In 1894 magnesia was not applied to any of the plots, but in view of the fact that soda is said to be sometimes beneficial, owing to its liberation of magnesia in the soil, an application of magnesia in the form of Epsom salts was made to each of the plots in 1895. In 1894 certain series of the plots received lime at the rate of two tons per acre, none having been applied in 1895.

In 1894, when the experiment was begun, care was taken in connection with those plots receiving sodium carbonate and potassium carbonate, to employ such quantities of each of these ingredients as would impart the same degree of alkalinity to the soil. This was done rather than to employ a like weight of each, in order to eliminate as far as possible, from the plots under direct comparison, the effect of unequal acidity[1] or alkalinity upon the growth of the plants. In the case of those plants receiving chlorids of potassium and sodium, the amounts of these ingredients employed were such as to furnish potassium and sodium at rates equivalent to those employed in the case of the potassium and sodium carbonates. In 1896 dried blood was employed at the rate of 1020 pounds per acre or 17 pounds per plot, dissolved boneblack at the rate of 600 pounds per acre or 10 pounds per plot, and finely ground phosphate rock (floats) at the rate of 480 pounds per acre or 8 pounds per plot. Each plot received, likewise, magnesium sulfate (Epsom salts) at the rate of 420 pounds per acre or 7 pounds per plot. Those plots which received lime in 1894 were again limed in 1896 at the rate 1200 pounds per acre of air-slacked lime or 20 pounds per plot. Full, three-quarters, half and quarter rations of the potassium and sodium salts were employed in a similar manner as in the two preceding years, the full rations in 1896 being as follows: potassium carbonate, 360 pounds per acre, equal to 6 pounds per plot; sodium carbonate, 240.6 pounds per acre, equal to 4.01 pounds per plot; muriate of potash, 394.4 pounds per acre, equal to 6.64 pounds per plot; sodium chlorid, 274.2 pounds per acre, equal to 4.57 pounds per plot. The subjoined diagram shows the arrangement of the plots and the plan of fertilization of each, which, so far as concerns potassium and sodium, has been continued in the same manner as in each of the two previous years. It should be stated here that, in the first two years of the experiment, plants were selected for trial upon these plots, some of which had given indications in other experiments, or by their chemical composition, that they might be benefited by soda, and others on the contrary which had not. Two years' observations with such plants having been obtained, it then seemed

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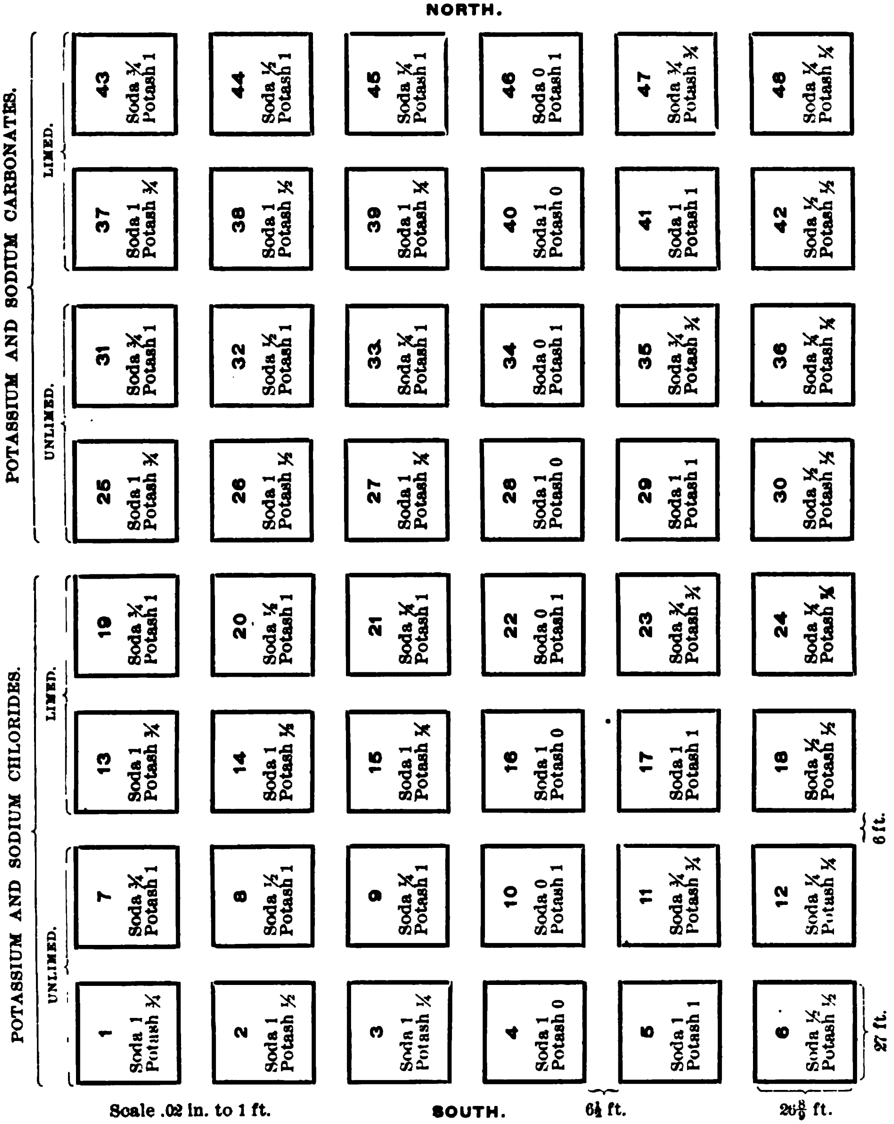
[1] Naturally if the plants take more potash than soda from the soil, inequalities in the acidity or alkalinity would result in consequence, which factor, as well as that of possible unequal leaching, it is, of course, impossible to control absolutely.

PLAN SHOWING THE ARRANGEMENT OF THE PLOTS AND THE KINDS OF FERTILIZING MATERIAL* APPLIED TO EACH.



NOTE.—The figures following the words "Potash" and "Soda" show whether the maximum amount or some fraction thereof was used.

* In addition, each plot (one-sixtieth acre) received like amounts of phosphoric acid, nitrogen and magnesia in the same form.

desirable to reduce the number of plants for a few years, and conduct the experiment in such a way as to exhaust the assimilable potash from the soil as rapidly as possible, in order that any differences which might be attributable to the use of soda might become more strikingly manifest. In order to accomplish this it was planned to grow if possible two crops per year upon this land, until some marked indications of a deficiency of potash might show themselves by those plants which received soda without any addition of potash. The general plan was to continue along this line so far as was necessary to accomplish this object, and then repeat the observations at a later period with the plants employed during the first two years. If soda is of particular value in connection with certain plants, and useless in connection with others, then by such an arrangement this point ought to become manifest.

In accordance with the plan outlined above, the two crops selected for 1896 were oats and millet, the oats being sown as early as possible, and cut while in the milk, so as to enable the millet to enjoy as long a period of growth as possible. During the period of growth no marked differences were observable in the appearance of the oats upon the several plots, and by an inspection of the crop upon the plots which received potash and no soda, and of those upon the ones beside them which received soda and no potash, no particular difference was visible; yet upon a comparison of the weights, as given in the succeeding tables and diagrams (*diagrams 1 and 3*), it will be seen that though not visible there was some difference in the amount of crop secured from the different plots.

In marked contrast with the oats the millet showed a very decided advantage from the use of potash, as compared with soda. The growth upon those plots where soda was used without potash was markedly inferior, and where potash in increasing quantities was used in connection with soda, the height of the crop rose with each increase of potash. Where soda was added to potash, there was, as seen by the succeeding tables and diagrams (*diagrams 2 and 4*), in some cases an apparent advantage, yet this was so much

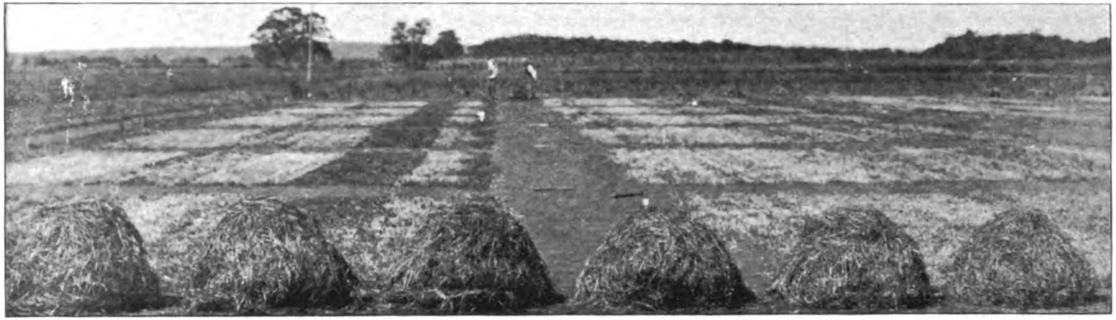


FIG. 1.—MILLET.

Potassium and Sodium Chlorids. *Unlimed.*

Potash ration	1	1	1	1	¾	¼
Soda ration	¾	½	¼	0	¼	¼

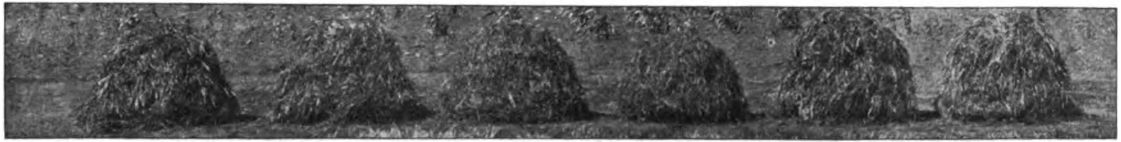


FIG. 2.—MILLET.

Potassium and Sodium Chlorids. *Unlimed.*

Potash ration	¼	½	¼	0	1	½
Soda ration	1	1	1	1	1	½

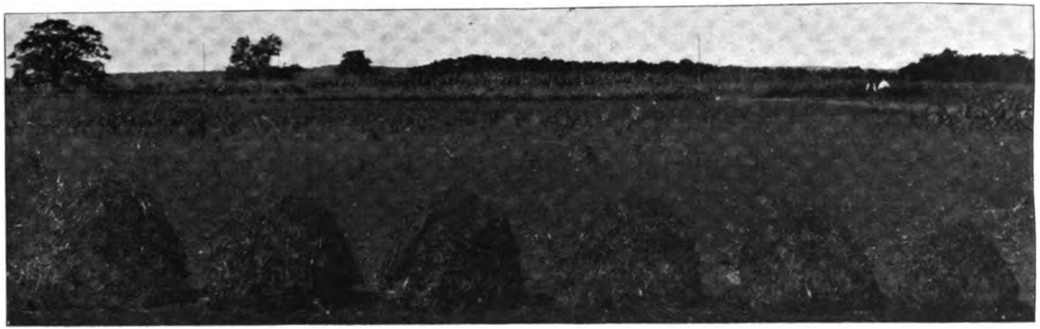


FIG. 3.—MILLET.
Potassium and Sodium Chlorids. *Limed.*

Potash ration	1	1	1	1	¾	¼
Soda ration	¾	½	¼	0	¾	¼

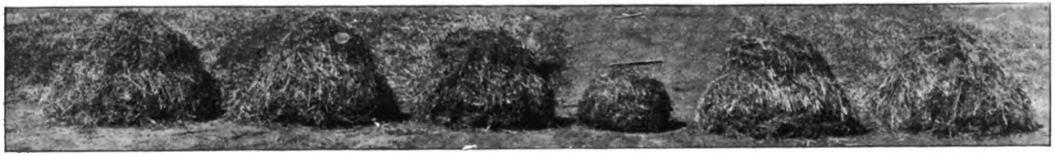


FIG. 4.—MILLET.
Potassium and Sodium Chlorids. *Limed.*

Potash ration	¾	½	¼	0	1	½
Soda ration	1	1	1	1	1	½

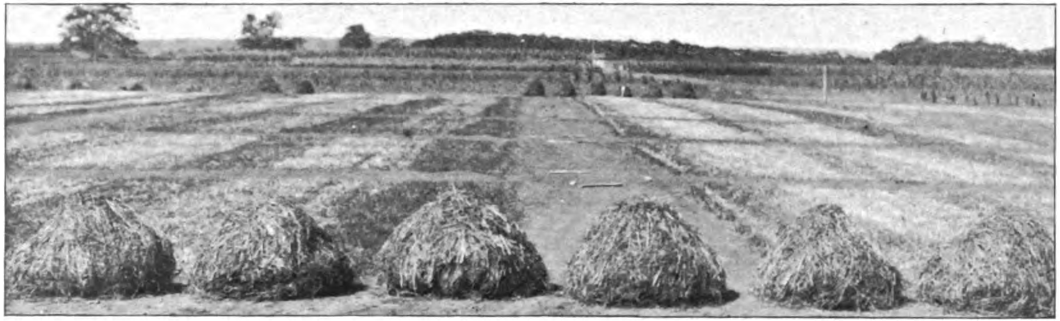


FIG. 5.—MILLET.
Potassium and Sodium Carbonates. *Unlimed.*

Potash ration	1	1	1	1	¾	¼
Soda ration	¾	½	¼	0	¾	¼

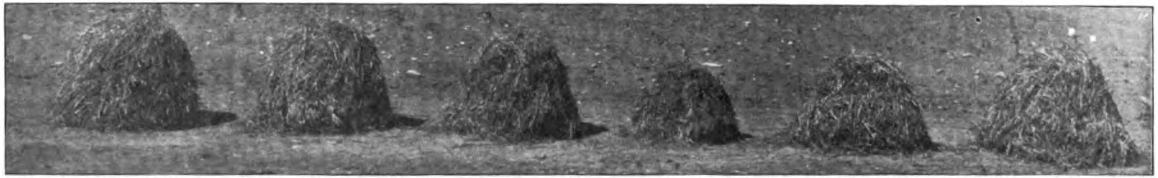


FIG. 6.—MILLET.
Potassium and Sodium Carbonates. *Unlimed.*

Potash ration	¾	½	¼	0	1	½
Soda ration	1	1	1	1	1	½

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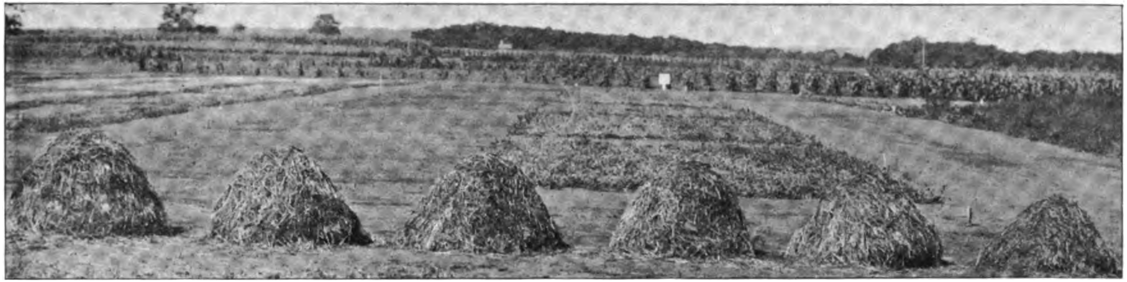

Fig. 7.—Millet.

Potassium and Sodium Carbonates. ***Limed.***

Potash ration	**1**	**1**	**1**	**1**	**¾**	**¼**
Soda ration	**¾**	**½**	**¼**	**0**	**¾**	**¼**

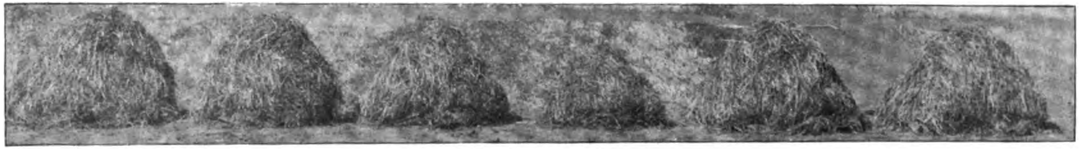

Fig. 8.—Millet.

Potassium and Sodium Carbonates. ***Limed.***

Potash ration	**¾**	**½**	**¼**	**0**	**1**	**½**
Soda ration	**1**	**1**	**1**	**1**	**1**	**½**

less than in the case of the addition of potash to the soda ration, that it was not readily apparent upon casual inspection. Unfortunately when the millet was hardly one-third grown army worms appeared upon all of the plots, whereupon the crop was immediately harvested and weighed. Had the crop not been prematurely harvested the contrast upon the potash and soda plots would doubtless have been even more marked.

From the foot note in connection with the tables which follow, it will be seen that reference is made to injury done to certain of the plots by geese. This was occasioned by an attack made by dogs upon the geese under experiment upon the Station farm. The geese were driven by their pursuers across portions of certain plots while the oats were from eight to ten inches high. The oats recovered to a large extent from the injury thus received, but the yield was doubtless somewhat affected thereby, so that it became necessary to take this disturbing factor into consideration in reporting upon the results.

POTASSIUM AND SODIUM CARBONATES.

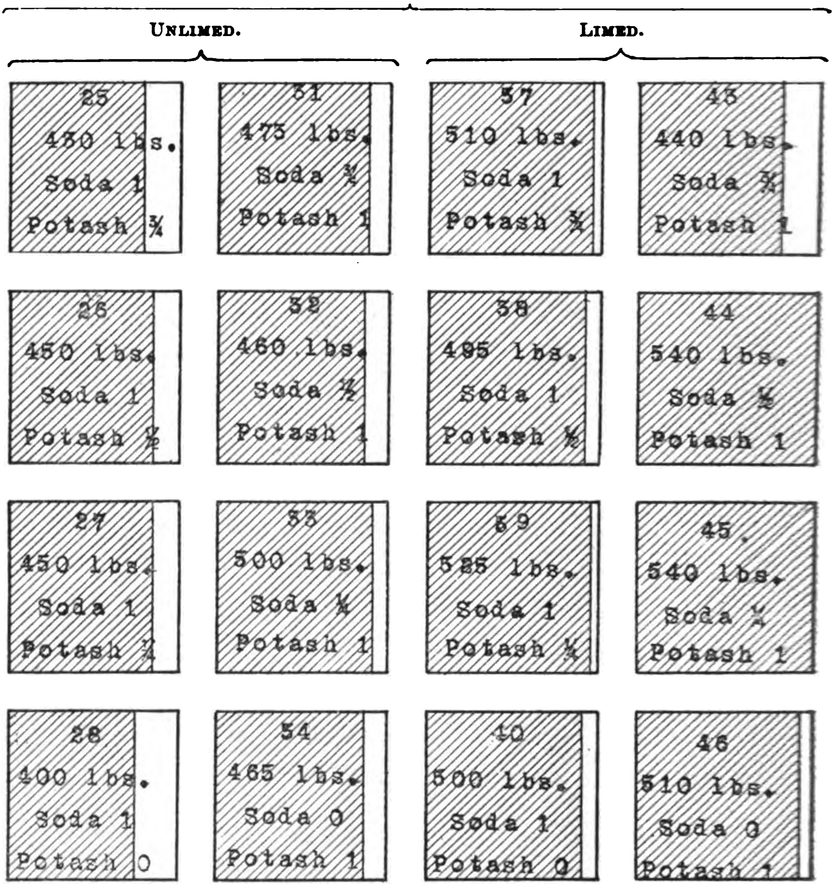

DIAGRAM 8.

This diagram shows the relative position of the plots, and the cross-lined portions the yield of the *first* crop (oat fodder, green), in 1896. The upper figures show the number of the plot; those next below, the weights of oat fodder; the next, what part of a ration of sodium, and the bottom ones, what part of a ration of potassium was applied to each.

POTASSIUM AND SODIUM CHLORIDS.

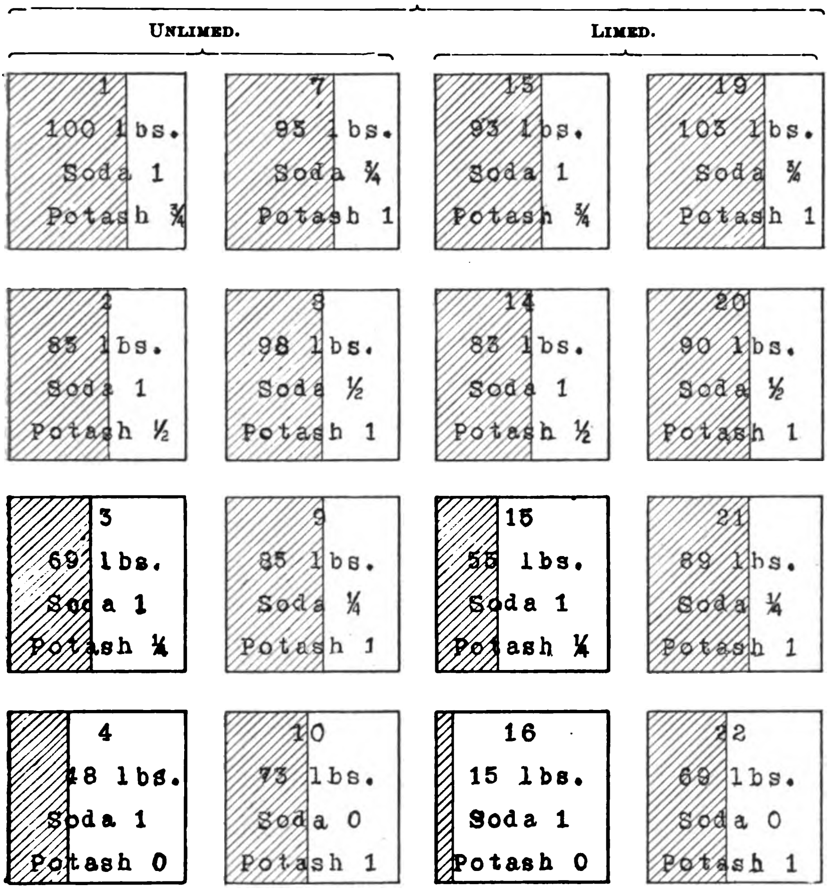

DIAGRAM 2.

This diagram shows the relative position of the plots, and the cross-lined portions the yield of the *second* crop (millet, green), in 1896. The upper figures show the number of the plot; those next below, the weights of millet; the next, what part of a ration of sodium, and the bottom ones, what part of a ration of potassium was applied to each.

POTASSIUM AND SODIUM CHLORIDS.

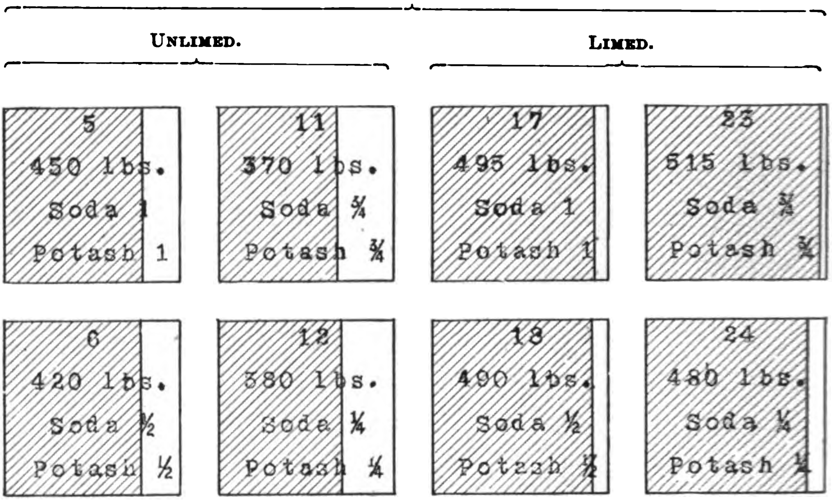

DIAGRAM 5.

This diagram shows the relative position of the plots, and the cross-lined portions the yield of the *first* crop (oat fodder, green), in 1896. The upper figures show the number of the plot; those next below, the weights of oat fodder; the next, what part of a ration of sodium, and the bottom ones, what part of a ration of potassium was applied to each.

POTASSIUM AND SODIUM CHLORIDS.

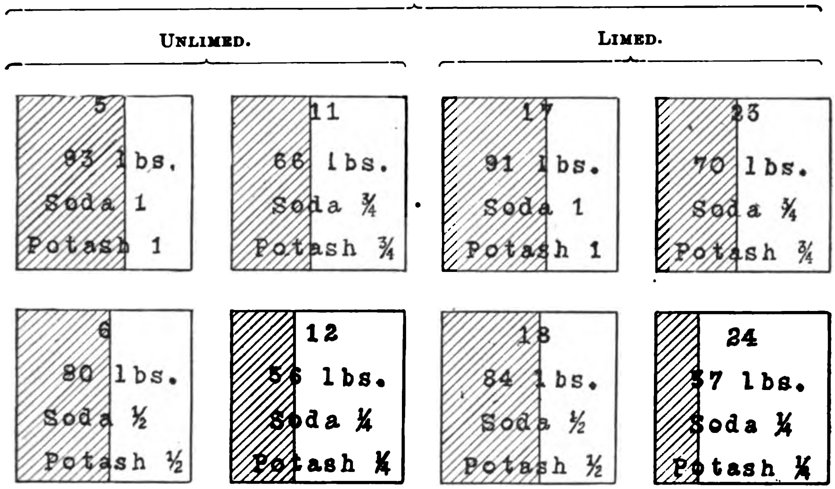

DIAGRAM 6.

This diagram shows the relative position of the plots, and the cross-lined portions the yield of the *second* crop (millet, green), in 1896. The upper figures show the number of the plot; those next below, the weights of millet; the next, what part of a ration of sodium, and the bottom ones, what part of a ration of potassium was applied to each.

TABLE I.

Showing Yields, in Pounds, of Oats and Golden Millet, where compounds of Potassium and Sodium were used separately and combined in various proportions.

Date of Harvesting.		SODIUM CHLORID AND POTASSIUM CHLORID.																							
		UNLIMED.												LIMED.											
	Soda ration........	1	¾	1	½	1	¼	1	0	1	¾	½	¼	1	¾	1	½	1	¼	1	0	1	¾	½	¼
	Potash ration.....	¾	1	½	1	¼	1	0	1	1	¾	½	¼	¾	1	½	1	¼	1	0	1	1	¾	½	¼
	Plot number......	1	7	2	8	3	9	4	10	5	11	6	12	13	19	14	*20	15	21	16	22	17	23	18	24
July 11............	Oats	370	425	385	450	385	480	400	370	430	370	420	380	470	525	505	490	490	535	440	495	495	515	490	480
September 2......	Millet	100.5	93.5	83.8	98.0	69.5	85.0	48.8	73.3	93.3	66.8	80.0	56.0	98.5	103.5	83.8	90.8	55.0	89.8	15.0	69.0	91.8	70.0	84.0	37.8

TABLE II.

Date of Harvesting.		SODIUM CARBONATE AND POTASSIUM CARBONATE.																							
		UNLIMED.												LIMED.											
	Soda ration.......	1	¾	1	½	1	¼	1	0	1	¾	½	¼	1	¾	1	½	1	¼	1	0	1	¾	½	¼
	Potash ration.....	¾	1	½	1	¼	1	0	1	1	¾	½	¼	¾	1	½	1	¼	1	0	1	1	¾	½	¼
	Plot number......	25	31	26	32	*27	*33	28	34	29	35	30	36	37	43	38	44	39	*45	40	*46	41	47	42	48
July 11............	Oats	430	475	450	460	450	500	400	465	420	450	470	440	510	440	495	540	525	540	500	510	535	490	515	465
September 2......	Millet.	83.8	67.8	68.0	65.5	58.0	76.8	22.0	71.8	52.0	55.0	67.0	51.8	111.5	158.8	78.0	110.0	67.0	128.5	81.0	95.5	106.0	92.8	88.8	52.8

* The oats were trampled upon in places by geese and dogs when about six inches high, which may have reduced the yields slightly.

By an examination of table 2 it will be seen that the yield in the case of the oats was slightly greater upon the plots which received potassium carbonate than upon those which received sodium carbonate, the same being true of both the limed and unlimed series. In the case of sodium chlorid and potassium chlorid the same is true in the limed series, while in the unlimed series the yield was slightly greater upon the soda than upon the potash plot. In connection with the millet, which followed the oats, it is noticeable that very marked differences in the yields from the potash and soda plots have now for the first time shown themselves, and in every instance in the case of the chlorids and carbonates of sodium and potassium, both upon the limed and unlimed plots, the yields from the potash plots were much greater than upon the corresponding ones which received soda. This difference between the results obtained with the oats and millet is readily accounted for, upon the supposition that the oats found at their disposal nearly all of the assimilable potash which they required, even upon those plots to which no potash had been applied. This crop, however, so far exhausted this supply that the millet which followed suffered seriously, owing to the deficiency of that ingredient. This point is strikingly brought out by the arrangement of the yields, as shown in diagrams 1 to 4 inclusive, where they are aligned in such a manner, that we have at the bottom in the one case the result from the use of soda alone, while the three results above it show the gain, if any, from the addition of quarter, half and three-quarter rations of potash to the full ration of soda. Alongside of these is arranged at the bottom the yield from the potash plot which received no soda, and above it the yields where quarter, half and three-quarter rations of soda were added to the potash. This arrangement is the same for both chlorids and carbonates of potassium and sodium, in the limed as well as the unlimed series. Upon an examination of these diagrams it will be seen that no definite conclusions can be drawn from the results secured with the oats, but in the case of the millet, it will be observed that, where potash in increasing quantities was added to the soda ration, the yields were increased in each instance, and in some cases in a marked degree. Where soda in increasing quantities was added to the full ration of potash, it will be seen that the crop was generally increased, though not in all cases, nor regularly; neither was the increase nearly as great as where increasing quantities of potash were added to the full ration of soda. In the case of the combinations of the full ration of potash with the full ration of soda, and of three-quarter rations of each, half rations of each, and quarter rations of each, the results are not as regular nor as uniform as in the case just cited. In fact, as has been stated in previous years, a slight lack of uniformity existed unavoidably in some of the plots, at the beginning of the experiment, a condition which will be expected to become less and less marked from year to year.

It is not our intention to attempt to draw definite and far-reaching conclusions from this experiment, until it has been conducted long enough to secure results of such marked character as may render the conclusions unquestionable. It must, however, be conceded, when we compare the results secured with the millet, in 1896, with those obtained with other crops in the two preceding years, that the inefficiency of soda, as compared with the potash in the forms employed, is becoming more and more manifest; and in fact it may be said to have become strikingly manifest in the case of the millet this season. In the first two years of the experiment a general increase of crop was noticeable, where increasing amounts of potash were added to the soda ration. Where the soda in increasing quantities was added to the potash ration, the results were so irregular as to afford no conclusion as to whether the soda had been of any benefit or not. The data of this season, particularly in connection with potassium and sodium chlorids in both the limed and unlimed series, and in connection with carbonates in the limed series, point to the probability that the soda had been of some advantage when added to the full ration of potash. The results upon the unlimed plots which received carbonates are as yet too irregular to furnish any reliable indication. It may be said, therefore, that the results of this season are the first which have furnished any marked indication of an advantage of the use of soda in connection with potash. It is our intention, however, if circumstances permit, to continue this experiment in the same line, and it is reasonable to suppose that by the removal of two crops annually for a few years, by which the immediately assimilable potash will be exhausted from the soil, that any advantage which may be derived from the use of soda will become more manifest.

A COMPARISON OF RESULTS OBTAINED FROM NITRATE OF POTASH, AND FROM MURIATE OF POTASH IN CONNECTION WITH NITRATE OF SODA.

This experiment was conducted upon the plots which were used for the same purpose in 1895,[1] which are referred to as the plots of the "gypsum experiment." Each of the plots received in 1895, as well as in 1896, like quantities of nitrogen, potash, phosphoric acid and magnesia. The latter ingredient was added in the form of Epsom salts. It was applied in order that a supply of directly assimilable magnesia might be at the disposal of the plants, so that if greater yields were obtained upon the plots where nitrate of soda was employed than upon those where nitrate of potash was used, it could not be argued that the sodium of the nitrate of soda had liberated magnesia within the soil, thereby causing the additional yield upon those plots. As will be seen by the accompanying diagram, three groups of two plots each were employed in this experiment. Upon one group no lime was used, upon another land plaster (gypsum), and upon a third air-slacked lime in an amount furnishing the same quantity of calcium as was supplied in the form of land plaster. The air-slacked lime and land plaster were applied in 1895, no further applications having been made in 1896. The quantities of the various ingredients employed in this experiment, in 1896, are given in the succeeding table:

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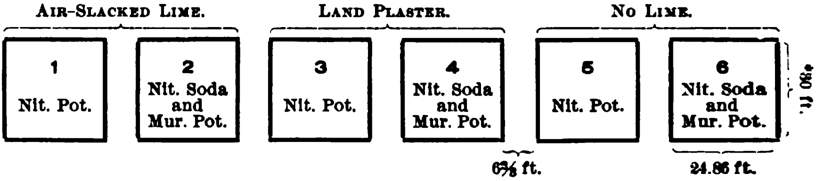
[1] Eighth An. Rep. R. I. Agrl. Expt. Sta., 1895, pp. 226-231.



In 1895 these plots were divided through the center, one kind of beets having been grown upon one-half of each of the plots, and another variety upon the other half of each. In 1896 this subdivision of the plots was continued, so as to obtain results with more than one plant, one side being seeded with clover and the other sown to barley and timothy. Owing to the failure of the timothy, it was reseeded after the removal of the barley.

Table showing the quantities of lime and fertilizer employed per acre, and the action of nitrate of potash as compared with the same amounts of nitrogen and potash in form of nitrate of soda and muriate of potash (weights of crops in pounds per plot).

NAME OF CROP.	5,000 lbs. of Air-Slacked Lime in 1895.†		9,805 lbs. of Land Plaster in 1895.†		No Lime.	
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
	Dissolved Boneblack, 800 lbs. Sulfate of Magnesia, 400 lbs. Nitrate of Potash, 450 lbs.	Dissolved Boneblack, 800 lbs. Sulfate of Magnesia, 400 lbs. Nitrate of Soda, 450 lbs. Muriate of Potash, 400 lbs.	Dissolved Boneblack, 800 lbs. Sulfate of Magnesia, 400 lbs. Nitrate of Potash, 400 lbs.	Dissolved Boneblack, 800 lbs. Sulfate of Magnesia, 400 lbs. Nitrate of Soda, 450 lbs. Muriate of Potash, 400 lbs.	Dissolved Boneblack, 800 lbs. Sulfate of Magnesia, 400 lbs. Nitrate of Potash, 450 lbs.	Dissolved Boneblack, 800 lbs. Sulfate of Magnesia, 400 lbs. Nitrate of Soda, 450 lbs. Muriate of Potash, 400 lbs.
Barley (total crop, air dried).......	28.00	28.50	22.00	16.00	6.00	6.50
Barley (grain)....	8.25	6.50	6.50	4.50	1.50	3.00
Clover (green)....	66.75	120.25	120.00	124.25	119.75	134.50

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* Published by mistake as 24 feet in the preceding Annual Report.

† The amounts of air-slacked lime and land plaster were such as to furnish the same amounts of lime (calcium oxid).

The results obtained by the use of lime in different forms, as well as upon the unlimed plots, are to be discussed in another connection. The point which comes under consideration here is merely as to the possible beneficial or injurious effect of the soda and chlorin upon the plots where the muriate of potash and nitrate of soda were used, comparing them with those where the same amount of nitrogen and potash, in the form of nitrate of potash, was employed.

It will be observed from inspection of the above table that, in the case of the air-slacked lime and unlimed plots, there was little or no difference between the nitrate of potash and the nitrate of soda and muriate of potash plots, as regards the total yields of barley (straw and grain). Upon the plots which received land plaster the total yield was greater upon that where nitrate of potash was employed. Comparing the yield of grain, however, it will be seen that upon the air-slacked lime and land plaster plots the yields were in both cases greater upon the plots which received nitrate of potash, than upon those where nitrate of soda was applied in connection with muriate of potash; but in the case of the unlimed plots the yield was greater upon that which received nitrogen and potash in the last mentioned two forms. In the case of the clover, only one cutting of which was made, late in the season, a greater yield was obtained in each case from the plot which received nitrate of soda and muriate of potash, than from that which received nitrate of potash. The difference, however, was not very great, except in one case, namely: that of the air-slacked lime plots, and this was probably due to unlike seeding caused by a high wind. At the time the clover seed was sown, the surface of the two plots which had been treated with air-slacked lime was dryer than the others. Shortly after the seeding an unusually high wind prevailed for several hours, carrying away clouds of dust, and with it, probably, unequal amounts of clover seed from the two plots which were dryest at the surface. The others, probably, lost little or no seed. Under such circumstances the data from the clover crop on the air-slacked lime plots cannot be considered as at all trustworthy. Practically all that can be said in relation to this experiment this season is that the indications afforded by the clover are the opposite of those furnished by the barley. It is possible, of course, that the soda and chlorin on those plots which received nitrate of soda and muriate of potash, may have been of some use to the clover plants but injurious to the barley. It is our intention to continne this experiment, if possible, long enough to secure data which will be so marked as to leave no room for further doubt as to the function of the chlorin and soda. The results are given here chiefly as a matter of record, and though particular features of the data secured this season are pointed out, no attempt whatever will be made to draw any conclusions at present. It would not be at all surprising if this experiment would have to be continued for a number of years before marked differences will be observable, and, in fact, upon the "soda substitution" experiment, upon plots immediately adjoining, the results from the comparative trial of soda and potash in various combinations have just begun to be strikingly manifest at the end of the third season's work.

SUMMARY.

The inferiority of soda in the absence of potash, as compared with potash in the absence of soda, has become more strikingly manifest, from year to year, in each of the three years of the experiment. Prior to 1896 the yields were frequently increased by the addition of potash to the full soda ration, and less frequently, if at all, with the addition of soda to the full potash ration. This season, however, in connection with the second crop (millet), the addition of increasing quantities of potash to the full soda ration has increased the crop, in the order of the increased application of potash in each instance. Soda added to the potash ration has this year, for the first time, given indications of probable usefulness, which, if not incidental, can only become strikingly manifest, if at all, as the depletion of the assimilable potash on the soda plots increases.

It would be too hasty to conclude *definitely* from this year's results that an addition of soda to the potash ration had been positively beneficial, and it may be sufficient at this time to state merely that the results are strongly indicative that such may be the case, a point which it is hoped may be determined in future years.

FURTHER OBSERVATIONS UPON THE GROWTH OF VARIOUS PLANTS UPON AN ACID UPLAND SOIL, LIMED AND UNLIMED.

H. J. WHEELER AND G. M. TUCKER.

This experiment is a continuation of that described in previous Reports of this Station,[1] and has been conducted upon the permanent experiment plots Nos. 23, 25, 27 and 29. Each plot has received annually a like amount of phosphoric acid, in the form of dissolved boneblack, and of potash, in the form of muriate of potash. A like amount of nitrogen was also applied annually to each plot, that on plots 23 and 25 having been in the form of sulfate of ammonia, and that on plots 27 and 29 in the form of nitrate of soda. One of the plots which received sulfate of ammonia (25) and one which received nitrate of soda (29) were limed, in 1893, with air-slacked lime, at the rate of 5,400 pounds per acre, and again, in 1894, at the rate of 1,000 pounds per acre. Since then no further applications of lime have been made. In 1893 and 1894 the results with most plants were better upon the limed nitrate of soda plot (29) than upon the corresponding one which received sulfate of ammonia. Several possible explanations for this suggest themselves, namely : owing to the fact that nitrate of soda would be expected to leave in the soil a basic residue and sulfate of ammonia an acid one, it seemed probable that the differences might be attributed in part, in some cases, to a difference in the reaction of the two plots, so far as concerned acidity and alkalinity. It was possible that there might have been some loss of nitrogen in the process of nitrification of the sulfate of ammonia.[1] It appeared possible, in view of the experiments of P. Wagner and Dorsch,[2] that the soda might have been of some manurial value in connection with certain of the crops. There was a possibility, likewise, that there might have been a deficiency of magnesia, and that the soda had acted as an indirect fertilizer in setting magnesia free. In order to eliminate this last possibility, an application of 200 pounds of magnesium sulfate (Epsom salts) was made per acre, in 1895, upon each of the four plots and, in 1896, this amount was increased to 400 pounds per acre.

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[1] Sixth An. Rpt. for 1893, pp. 224-252; Seventh An. Rpt. for 1894. pp. 152-267. and Eighth An. Rpt. for 1895, pp. 205-214.

During the four years of this experiment (1893, 1894, 1895 and 1896) recorded data have been secured with 100 varieties of plants. In addition to these, sweet potatoes were tested in 1893, and a beneficial effect of the lime upon the growth of the vines was noticed. A few small fruits and other plants have died to such an extent that they will have to be reset or replanted, as the case may be, before data of any value can be secured. Many incidental observations are on record in relation to the action of lime upon the growth of certain plants, yet we are not aware that any one has heretofore taken up this question systematically. For this reason it seems particularly desirable to continue these experiments long enough, so that practically all plants which are ever grown in our climate may ultimately be tested. In the course of the experiments thus far conducted it has been abundantly demonstrated that theories and suppositions, no matter how plausible they may appear, cannot be accepted in lieu of practical observations. For example, it has happened a number of times that parties who were already familiar with the fact that lime was of benefit to clover, have remarked, upon pointing out to them its great value in connection with alfalfa, " Oh yes, it is beneficial to the leguminous plants," taking it for granted that they are all alike in this particular. This does not seem to be the case, and our own observations are fully in accord with those of many European observers, to the effect that lupine is injured by liming, even for several years thereafter, and serradella and other leguminious plants have shown similar injury, the duration of which we have not yet had an opportunity to determine. Watermelons and cantaloupes, though so closely related botanically as to be classed in the same genus, furnish a fine illustration of the same principle, the former being seriously injured by liming, even on our acid soil, while the latter was a total failure without it. Again, barley and wheat have been invariably benefited in a marked degree, and oats to some extent, by applications of lime immediately prior to sowing the seed; rye has, on the other hand, shown positive injury from its use at that time, in cases where an abundance of directly assimilable nitrogen was at hand, but in cases where the lime had been applied a few years before, marked benefit from its application has been noticeable. Such observations as these indicate clearly that in the case of those plants which show an injury from liming, it will be necessary to ascertain how long this will continue, so that definite positions may be assigned to them in rotations in which lime is employed. It is hoped that these observations, supplemented by culture experiments and determinations of the relative acidity of the soils experimented upon, may furnish eventually a reasonable basis for judging, from a simple chemical test, as to the probable relative benefit or injury from lime upon certain groups of plants upon a given soil. Owing to the nature of the plants experimented with, in 1896, it is impossible to group the data into one table, as was the practice in the last two Reports; they will, therefore, be considered individually or in groups, beginning with the observations upon the grasses.

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[1] P. Wagner and Dorsch, Die Stickstoffdüngung. Berlin, 1892, p. 212.

[2] Ibid, pp. 227–242. Compare M. A. Pagnoul. Annales Agronomique. 17, (1891), pp. 539 and 541, and also A. Atterberg. Deut. landw. Presse, 1891, p. 1,085. Abs. in E. S. R., 3. p. 554.

EXPERIMENT WITH GRASSES.

AWNLESS BROME GRASS, *Bromus inermis*, (L.)

The following notes were taken upon the character of the growth upon the four plots, a few days before the crop was harvested and weighed:

Plot 23. The growth upon this plot was poor. Much meadow soft rush (*Juncus effusus*, L.), some common sorrel (*Rumex acetosella*, L.), traces of wood rush (*Luzula campestris*, D. C.), and an admixture of other not easily determinable grasses were present.

Plot 25. The growth was good, and it was almost free from other grasses and weeds.

Plot 27. The growth was medium, and it was very free from other grasses and weeds.

Plot 29. The same may be said of this plot in all particulars as of plot 25.

The following are the weights of material obtained immediately upon cutting: (*See illustration, Fig. 1.*)

Plot Nos.................................	23 lbs.	25 lbs.	27 lbs.	29 lbs.
Weights of material...	10.13	19.05	13.15	15.90

The inferiority of the unlimed plots (23 and 27) is apparent, particularly where nitrogen in form of sulfate of ammonia was used (plot 23).

MEADOW FOX-TAIL, *Alopecurus pratensis*, L.

Plot 23. The growth was good. No meadow fox-tail was discernible, the grass consisting chiefly of red top with a little Rhode Island bent, traces of meadow soft grass, and of a species of *Lollium*.

Plot 25. The growth was fair. But little meadow fox-tail was present, the grasses being chiefly red top with a little Rhode Island bent, much *Lollium*, and traces of meadow soft grass.

Plot 27. The growth appeared to be about equal to that on plot 25, though there was less meadow fox-tail. The grass was chiefly red top with a little Rhode Island bent and *Lollium*, and traces of meadow soft grass.

Plot 29. The growth was much like that on No. 25, and this plot was similar in other respects, except that it had relatively more meadow fox-tail and *Lollium*.

The weights obtained immediately upon cutting are as follows:

Plot Nos.	23	25	27	29
	lbs.	lbs.	lbs.	lbs.
Weights of material	26.7	25.3	27.7	24.6

In marked contrast to the awnless brome grass, it will be seen that the best results were obtained upon the unlimed plots. Just what the result would have been had the meadow fox-tail persisted and driven out the other grasses, it is impossible to say, yet it was readily noticeable that there was more meadow fox-tail on the limed than on the unlimed plots.

TALL FESCUE, *Festuca elatior*, L.

Plot 23. The growth was very poor. There was very little tall fescue, much meadow soft grass, considerable orchard grass, some red top, Rhode Island bent and common sorrel, also a little *Lollium* and bog-rush.

Plot 25. The growth was good, and there was relatively less meadow soft grass and *Lollium* than on either plot 27 or 29.

Plot 27. This was similar to plot 29, except that there was relatively more red top and *Lollium*, and the growth was not as good.

Plot 29. The grass was chiefly tall fescue, mixed with considerable orchard grass, meadow soft grass and common sorrel, a little *Lollium*, traces of red top, and other undetermined grasses.

The following are the weights of the material as cut:

Plot Nos.	23	25	27	29
	lbs.	lbs.	lbs.	lbs.
Weights of material	24.45	34.10	22.40	33.65

In this case, with the predominance of tall fescue and orchard grass with considerable meadow soft grass, much better results are noticeable from the limed plots (25 and 29) than from the unlimed ones.

KENTUCKY BLUE GRASS, *Poa pratensis*, L.

Plot 23. Kentucky blue grass was almost wholly lacking, there being a trace of red top and no clover. The land was occupied chiefly by common sorrel and meadow soft rush. There were also a few miscellaneous weeds.

Plot 25. Kentucky blue grass was prominent on this plot; there was also rather more red top than on plot 29, and much more meadow soft rush, though the latter was very small in size as compared with that on plot 23. There was also upon this plot more sorrel and less clover than upon plot 29, but less sorrel than upon plot 27. But few miscellaneous weeds were present.

Plot 27. Upon this plot there was comparatively little Kentucky blue grass and considerable red top. White clover was almost lacking. There was a large amount of meadow soft rush, very evenly distributed, and but little wood rush. The growth was irregular and poor.

Plot 29. The growth, which was uniform and good, consisted chiefly of Kentucky blue grass, with some white clover and very little red top. The amount of common sorrel and other weeds was very small, and meadow soft rush was scarce.

The total weights of material, immediately upon harvesting, are given below:

Plot Nos.	23	25	27	29
	lbs.	lbs.	lbs.	lbs.
Weights of material	14.45	16.50	14.10	17.00

It will be seen that the total weights were greater upon the limed plots (25 and 29) than upon the unlimed ones. In order to bring out the interesting points referred to in the notes above, the material grown upon plots 23 and 25 (the unlimed and limed sulfate of ammonia plots) was assorted into four lots and weighed (*See illustrations, Figs. 2 and 3*), with the following result:

	Plot 23. lbs.	Plot 25. lbs.
Kentucky blue grass[1]	0.05	1.05
White clover	0.00	0.02
Meadow soft rush	4.10	0.05
Miscellaneous grasses[1] and weeds	7.80	12.70

From the foregoing it will be seen that Kentucky blue grass almost wholly failed upon the unlimed sulfate of ammonia plot, resembling, in this particular, sorghum and barley, which, so far as concerns their susceptibility to injury on this plot, stood in strong contrast to rye. Though the weight of white clover obtained on plot 25 was extremely small, it was, nevertheless, quite noticeable before it was cut, while upon the unlimed plot not a trace of it was discernible. Aside from the relative difference in the amount of Kentucky blue grass upon the two plots, that of the meadow soft rush was the most striking.

RED TOP, *Agrostis vulgaris*, With.

The grass consisted almost wholly of red top, and the growth was good on all four of the plots. On plots 25 and 29 there was a little timothy mixed with the red top, while the quantity of the latter grass decreased on plot 27 and still more on plot 23.

The following are the weights of undried material obtained upon cutting: (*See illustration, Fig. 4.*)

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[1] Owing to the extreme difficulty encountered in attempting to separate *all* of the leaves of Kentucky blue grass from the leaves of other grasses, the flower stalks only with such leaves as were attached to them were included in that separate portion given as Kentucky blue grass. For the purpose of comparing the relative growths upon plots 23 and 25, this was probably just as satisfactory as it would have been had the separation been complete. Probably a considerable portion of the material classed as miscellaneous grasses and weeds consisted, in the case of plot 25, of leaves of Kentucky blue grass.

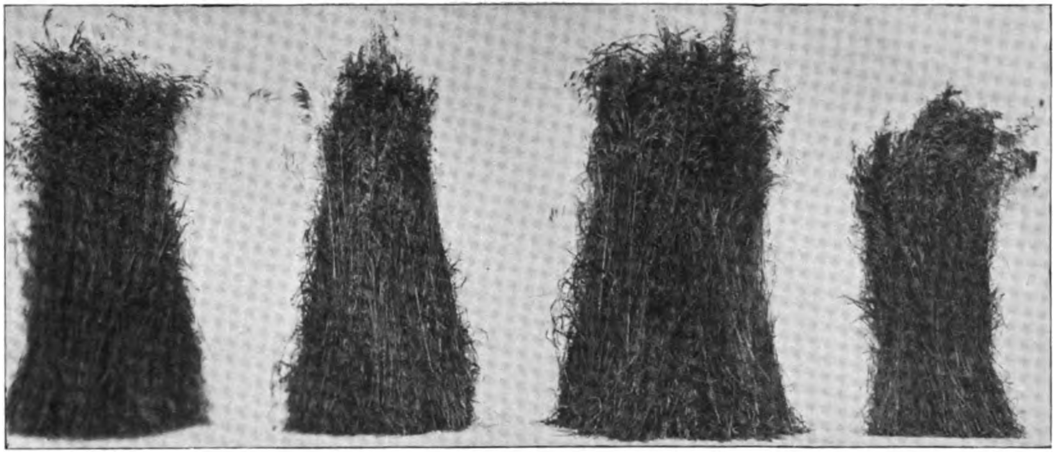

FIG. 1.—AWNLESS BROME GRASS.

Plot 29. *Limed.* Plot 27. *Unlimed.* Plot 25. *Limed.* Plot 23. *Unlimed.*

Nitrate of Soda. Sulfate of Ammonia.

All manured alike with potash and phosphoric acid.

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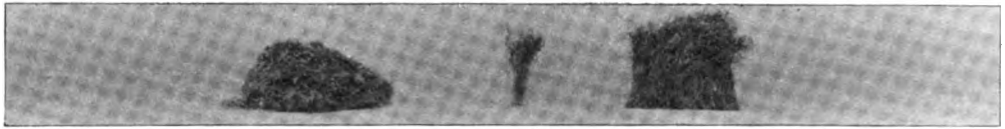

Fig. 2. *Unlimed* Sulfate of Ammonia plot, 23.

Miscellaneous grasses and weeds. Kentucky Blue Grass. Meadow Soft Rush. No Clover.

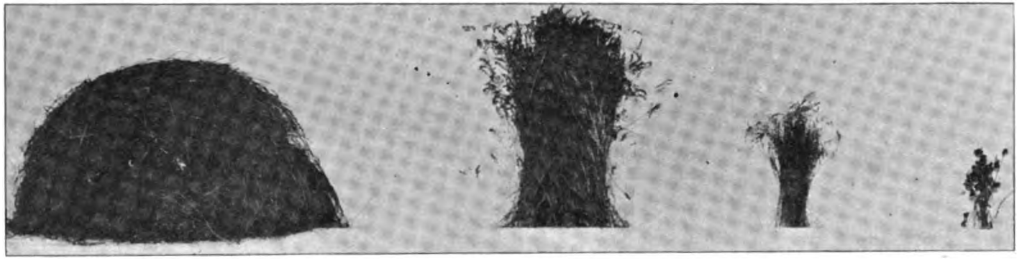

Fig. 3. *Limed* Sulfate of Ammonia plot, 25.

Miscellaneous grasses and a few weeds. Kentucky Blue Grass. Meadow Soft Rush. White Clover.

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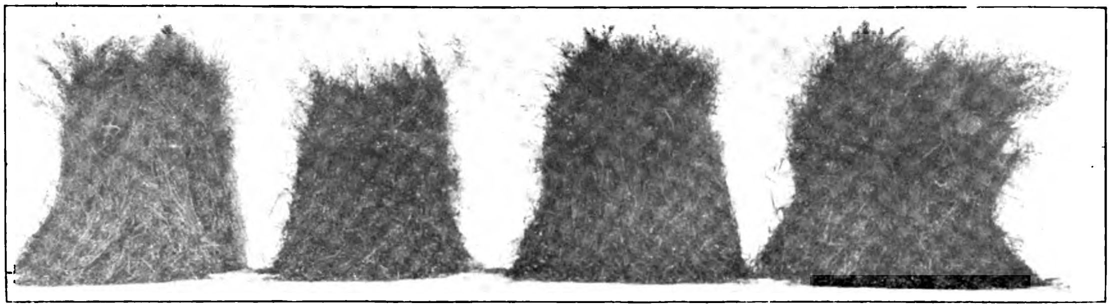

Fig. 4.—Red Top.

Plot 29. *Limed.* Plot 27. *Unlimed.* Plot 25. *Limed.* Plot 23. *Unlimed.*
Nitrate of Soda. Sulfate of Ammonia.
All manured alike with potash and phosphoric acid.

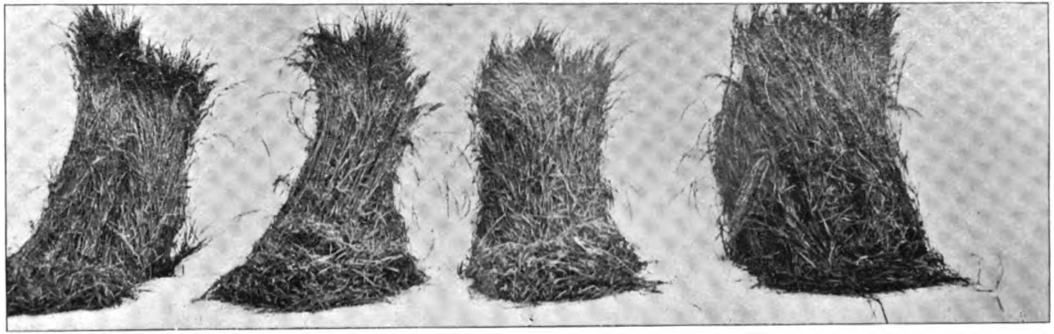

Fig. 5.—Meadow Oat Grass.

Plot 23. *Unlimed.* Plot 25. *Limed.* Plot 27. *Unlimed.* Plot 29. *Limed.*
Sulfate of Ammonia. Nitrate of Soda.
All manured alike with potash and phosphoric acid.

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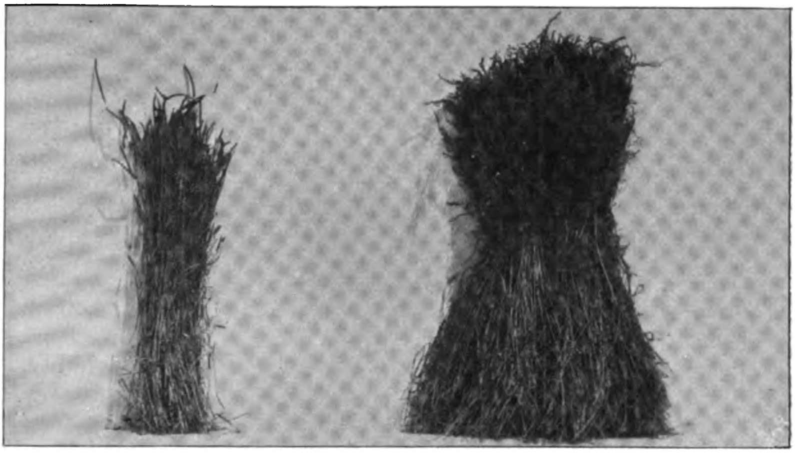

FIG. 6.

Timothy. **Red Top.**

Plot 23. *Unlimed* **Sulfate of Ammonia plot.**

With the exception of the fact that this was *unlimed* **it was treated in every respect like Plot 25. See Fig. 7.**

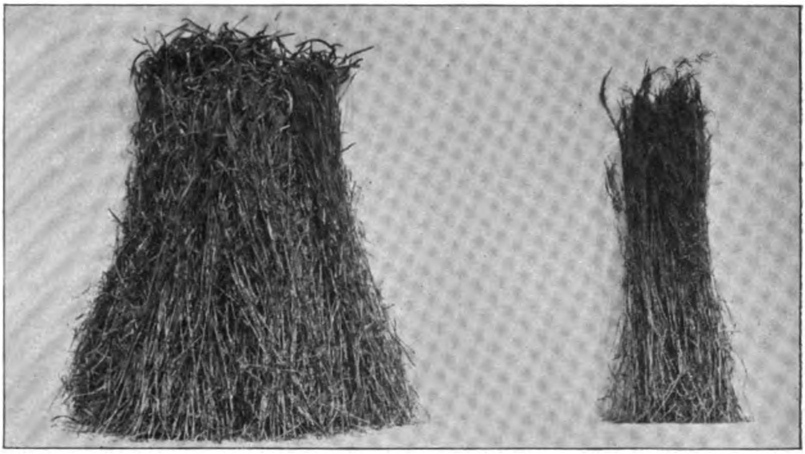

FIG. 7.

Timothy. **Red Top.**

Plot 25. *Limed* **Sulfate of Ammonia plot.**

With the exception of the fact that this was *limed* **it was treated in every respect like Plot 23. See Fig. 6.**

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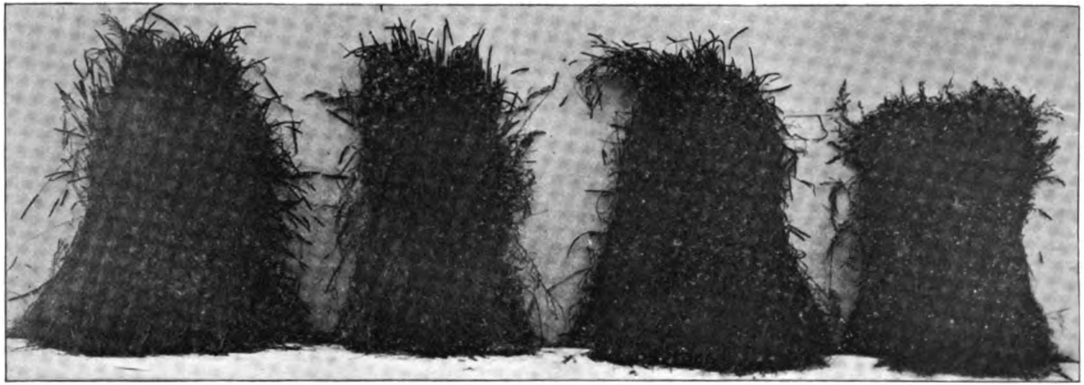

FIG. 8.—TIMOTHY.

Plot 29. *Limed.* Plot 27. *Unlimed.* Plot 25. *Limed.* Plot 23. *Unlimed.*

Nitrate of Soda. Sulfate of Ammonia.

All manured alike with potash and phosphoric acid.

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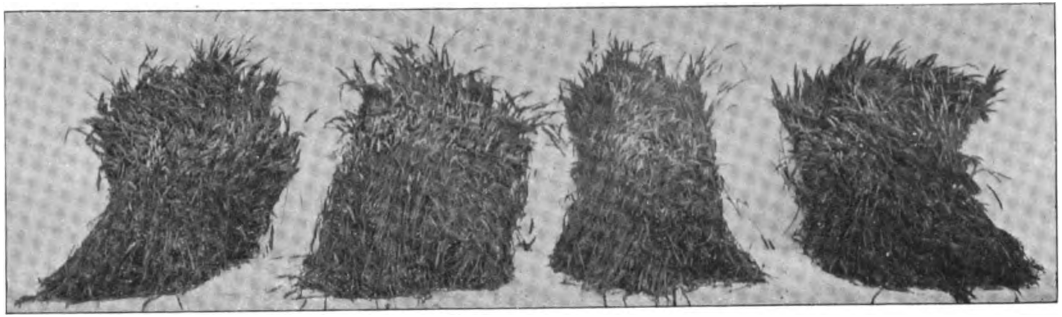

FIG. 9.—MEADOW SOFT GRASS.

Plot 28. *Unlimed.* Plot 25. *Limed.* Plot 27. *Unlimed.* Plot 29. *Limed.*

Sulfate of Ammonia. Nitrate of Soda.

All manured alike with potash and phosphoric acid.

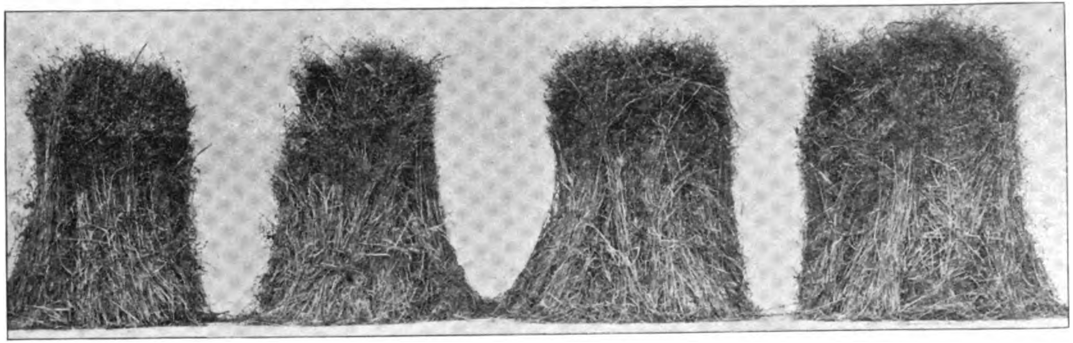

FIG. 10.—RHODE ISLAND BENT.

Plot 29. *Limed.* Plot 27. *Unlimed.* Plot 25. *Limed.* Plot 23. *Unlimed*

Nitrate of Soda. Sulfate of Ammonia.

All manured alike with potash and phosphoric acid.

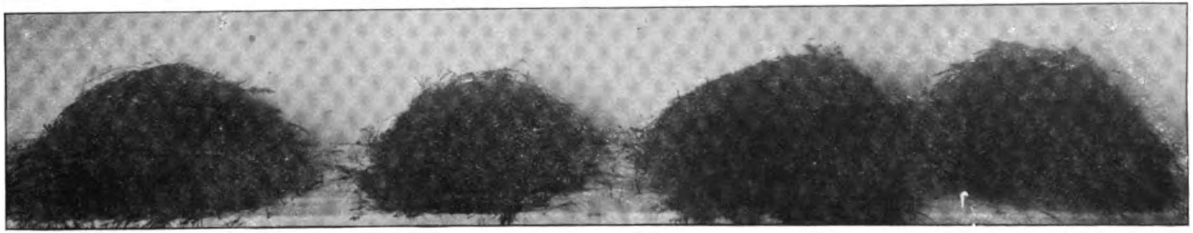

FIG. 11.—SHEEP'S FESCUE.

Plot 29. *Limed.* Plot 27. *Unlimed.* Plot 25. *Limed.* Plot 23. *Unlimed.*

Nitrate of Soda. Sulfate of Ammonia.

All manured alike with potash and phosphoric acid.

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Plot Nos.	23	25	27	29
	lbs.	lbs.	lbs.	lbs.
Weights of material	32.25	29.65	27.45	25.75

The results with red top are seen to stand in strong contrast with those with Kentucky blue grass and timothy, for in the latter cases, and particularly in that of the Kentucky blue grass, they were almost complete failures upon the unlimed sulfate of ammonia plot (23). The result was slightly better upon the limed sulfate of ammonia plot (25) than upon the corresponding one which received nitrate of soda.

ORCHARD GRASS, *Dactylis glomerata*, L.

Plot 23. Upon this plot there was very little orchard grass, the herbage consisting chiefly of meadow soft grass, with considerable *Lollium* and common sorrel, and a little Rhode Island bent grass. The growth was medium.

Plot 25. The herbage consisted chiefly of orchard grass, with considerable *Lollium* and meadow soft grass. The growth was good.

Plot 27. The herbage was practically the same as that of plot 25, with traces of Rhode Island bent grass and red top. The growth appeared to be better than upon plot 23, but inferior to that upon plots 25 and 29.

Plot 29. The character and growth of the herbage was about the same as upon plot 25.

The following are the weights of undried material:

Plot Nos.	23	25	27	29
	lbs.	lbs.	lbs.	lbs.
Weights of material	24.40	29.30	25.30	34.55

It will be seen from the foregoing notes that orchard grass was like Kentucky blue grass and timothy, so far as concerned its inability to flourish on the unlimed sulfate of ammonia plot (23); it was, however, much less injured than Kentucky blue grass, and perhaps slightly less so than timothy. In contrast to the results where certain other grasses predominated, it appears that a considerably greater yield was obtained upon the limed nitrate of soda plot than upon the limed plot which received sulfate of ammonia.

MEADOW OAT GRASS, *Avena elatior*, L.

This grass was not appreciably contaminated by an admixture of other grasses upon any one of the four plots.

The following are the weights of undried grass taken immediately upon cutting: (*See illustration, Fig. 5.*)

Plot Nos.	23	25	27	29
	lbs.	lbs.	lbs.	lbs.
Weights of material	20.50	24.15	24.30	28.10

This grass, like the orchard grass, gave better returns upon the limed nitrate of soda plot than upon the corresponding one manured with sulfate of ammonia. Whether this was due to some specific manurial action of the soda, or to a probable difference in the acidity of the two plots in consequence of the different action of the two combinations of nitrogen employed, or was merely incidental, remains to be ascertained.

TIMOTHY, *Phleum pratense*, L.

This grass was mixed with a large amount of red top on plot 23, with a considerable quantity on plot 27, and with much smaller quantities on the two limed plots (25 and 29). The seed sown, like that of all the other grasses mentioned in this experiment, was exactly the same in kind and quantity upon each of the four plots. It was most strikingly apparent, however, as the season of 1896 advanced, that on the *unlimed* sulfate of ammonia plot (23) there was comparatively little timothy and a fine growth of red top, while upon the *limed* sulfate of ammonia plot the reverse was true. The same was true also of the unlimed and limed nitrate of soda plots. This was such a striking feature that these two grasses were carefully separated from each other upon each of the sulfate of ammonia plots, and the respective bunches of each photographed, a reproduction of which is given. (*See Figs. 6 and 7.*) The weights of grasses are those of undried material, and represent the total weight of the respective mixtures on each of the four plots: (*See illustration, Fig. 8.*)

Plot Nos.	23	25	27	29
	lbs.	lbs.	lbs.	lbs.
Weights of material	21.10	31.05	25.30	30.80

The greater weights upon the limed than on the unlimed plots are, without doubt, due to the wonderful influence of the lime upon the growth of timothy, for where lime was applied this grass gained the supremacy. Upon the unlimed plots, and particularly upon that one where sulfate of ammonia was used (which it was supposed had increased its natural acidity), the conditions were highly unfavorable to the timothy, though apparently not so to the red top. It may be possible that a marked acid condition is not favorable to the growth of red top, but that it can thrive under almost all conditions. The fact that red top, where sown alone, yielded a smaller product in both instances upon the limed plots, points to a possibility of its thriving best on acid soil. The observations in relation to the effect of liming upon the growth of timothy, are in full accord with those heretofore recorded.[1]

MEADOW SOFT GRASS, *Holcus lanatus*, L.

This grass was practically free, upon all of the plots, from weeds or admixtures of other grasses. This grass was able to make a very vigorous growth upon the unlimed sulfate of ammonia plot (23), and to fully occupy the ground, even though it exhibited a marked benefit from liming.

The weights of undried grass are as follows: (*See illustration, Fig. 9.*)

Plot Nos.	23	25	27	29
	lbs.	lbs.	lbs.	lbs.
Weights of material	19.15	26 20	20.92	24.50

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[1] Eighth An. Rpt. R. I. Agrl. Expt. Station, pp. 195 and 212.

It will be seen that this grass was not only benefited by lime in connection with sulfate of ammonia, but also where nitrogen was employed in the form of nitrate of soda.

RHODE ISLAND BENT, *Agrostis canina*, L.

Plot 23. Aside from a small amount of red top, the herbage of this plot was almost exclusively Rhode Island bent grass. The growth was good.

Plot 25. The growth upon this plot was good, but there was more red top than on plot 23, and also traces of timothy.

Plot 27. The growth of Rhode Island bent upon this plot was poorest of all; there was also less red top than on plot 25. Traces of wood rush and of common sorrel were readily noticeable.

Plot 29. The growth of Rhode Island bent was good. There was more red top than on plot 27, and also traces of timothy.

The following are the weights of undried material: (*See illustration, Fig. 10.*)

Plot Nos.	23	25	27	29
	lbs.	lbs.	lbs.	lbs.
Weights of material	29.50	25.35	19.30	22.70

This grass was grown across one end of the plots, and the close proximity to the uncultivated paths may have been the cause of the apparently slightly contradictory results. One point is certain, namely: that this grass is not injured in a serious degree upon an acid soil, and that it can thrive where Kentucky blue grass and timothy are practically unable to exist. Thus we have still further evidence why this grass and red top take so kindly to our Rhode Island soil, while the two grasses mentioned above are more rarely seen in considerable quantities. An acid soil is, therefore, in one respect, adapted to the growth of red top or Rhode Island bent for seed purposes, for it is destructive to certain other grasses which, on a soil suitable to their growth, would prove more persistent.

SHEEP'S FESCUE, *Festuca ovina*, L.

The herbage on all four plots was almost exclusively sheep's fescue. The only other plant readily noticeable was white clover, which was present in considerable quantity on the two limed plots (25 and 29), while upon plot 23 but one plant, and on plot 27 but two plants, were discernible.

The weights of undried material are as follows: (*See illustration, Fig. 11*).

Plot Nos.	23	25	27	29
	lbs.	lbs.	lbs.	lbs.
Weights of material	11.50	13.90	7.55	11.40

It will be seen from the above that even though the sheep's fescue was benefited in each instance by liming, it was, nevertheless, able to make a good growth on the unlimed sulfate of ammonia plot (23), and the indications are that it stands in its ability to endure soil acidity, or in regard to its need of lime, between red top and Rhode Island bent on the one hand, and Kentucky blue grass and timothy on the other.

FURTHER TRIALS OF LIME WITH MISCELLANEOUS CROPS.

The miscellaneous crops, the data in connection with which are given below, were planted in rows running across the four plots.

The manuring was at a uniform rate in each case over the entire plot, covering alike the portions occupied by grasses, miscellaneous crops, small fruits, orchard fruits, and forest trees. The quantities of fertilizers employed are shown in the subjoined table, and the dates of liming, and the quantities applied are mentioned on page 242.

Plot Numbers	23	25	27	29	Per cent. of gain (+) or loss (—) on plot 29 relative to plot 25.	Yields on plot 29, reckoning those on plot 27 as 1.
Fertilizers Applied in 1896.	**Pounds Per Acre.**					
Dissolved boneblack	800	800	800	800		
Muriate of potash	300	300	300	300		
Sulfate of magnesia	400	400	400	400		
Sulfate of ammonia*	353	353	—	—		
Nitrate of soda*	—	—	465	465		
	Yield Per Row, in Pounds.					
	Unlimed.	Limed.	Unlimed.	Limed.		
Blue lupine (undried)	10.35	10.00	9.00	7.10		
Blue lupine (air-dried)	2.07	2.13	1.68	1.31	—38.4	.77
Early sown barley, North row	0.15	21.75	10.55	21.25	—2.2	2.01
Early sown barley, South row	0.15	28.75	8.70	22 95	—19.0	2.63
Late sown barley, North row	1.10	2.20	0.70	2.60	+18.2	3.71
Late sown barley, South row	0.50	4.10	1.90	3.60	—12.2	1.89
Beets (mangel wurzel)	trace.	69.50	18.25	104.75	+50.7	5.73
Crimson clover	0.50	25.50	17.00	27.15	+6.5	1.59
Carrots, North row	trace.	26.00	30.00	31.50	+21.2	1.05
Carrots, South row	trace.	25.00	9.25	34.00	+36.0	6.67
Dandelions	0.00	3.25	2.40	6.80	+109.2	2.83
Rye	3.00	4.25	3.00	4.15	—2.4	1.38
Spinach	0.00	2.90	0.20	4.10	+41.4	20.50
Gladiola (bulbs)	11.70	10.00	12.20	10.70	+7.0	.87

COMMENTS UPON THE RESULTS WITH CERTAIN MISCELLANEOUS PLANTS.

Blue lupine. The results with blue lupine are particularly interesting, taken in connection with those secured in previous years. It should be remembered that 5,400 pounds of air-slacked lime, per acre, were used on one of the sulfate of ammonia, and one of the nitrate of soda plots, in 1893, shortly prior to the time of planting. In 1894, an application of 1,000 pounds per acre additional was again made to each, no further applications being made in 1895 and 1896.

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* The quantity of nitrogen applied to each plot was identical. In order that this might be the case each year, the relative amounts of sulfate of ammonia and nitrate of soda are changed each season to accord with their varying chemical composition.

In order to facilitate comparisons, the results for the four years are grouped below: (*For illustration of lupine grown in 1896, see Fig. 12.*)

WEIGHTS OF BLUE LUPINE AFTER AIR-DRYING.

(Weights in pounds.)

Plot Nos.		1893.	1894.	1895.	1896.
23.	Unlimed sulfate of ammonia plot.......	2.97	2.9	5.92	2.07
25.	Limed " " " "	1.21	2.9	5.99	2.13
27.	Unlimed nitrate of soda plot...........	3.28	6.0	8.71	1.68
29.	Limed " " " "	1.54	1.4	5.48	1.31

It will be seen from the foregoing that the poorest results were obtained upon the limed nitrate of soda plot (29), where most other plants have, as a rule, done the best. On the other hand, in three out of the four years the best results have been obtained upon the unlimed nitrate of soda plot (27). By comparing the results upon these two plots it is observable that the greatest injury from the use of lime resulted in the first two seasons, where some lime was probably still present in the caustic state. Comparing the two sulfate of ammonia plots, no injury is noticeable from liming, except the first season, when the amount of lime in a caustic state must have been great. Whether the marked superiority of the results on the unlimed nitrate of soda plots, as compared with those on either of the sulfate of ammonia plots, was due to some advantage derived from the soda, either as a direct or indirect manurial agent, is not apparent. It is, perhaps, possible that the degree of acidity existing on plot 27 particularly adapted that plot for lupines, and that the disadvantage from liming on plot 25 was practically compensated for by a too great degree of acidity on plot 23, each of which may have furnished unfavorable extremes. The results for 1896 do not, however, accord with this idea, but since the character of the season may exert a marked influence, it is obvious that further observations are necessary before definite conclusions can be drawn. When considering the results for the year 1893, where much injury resulted (evidently due to the caustic character of the lime), it was suggested[1] that the whole question might hinge upon some effect of the lime upon the development, upon the roots, of the organisms by which the assimilation of atmospheric nitrogen is affected. At the suggestion of Tacke, Salfeld[2] made examinations of the roots of peas and certain other leguminous plants which had been seriously injured by applications of caustic lime, and found no root nodules upon the injured plants, while the few in a vigorous condition showed the nodular development. Heinrich[3] finds that magnesium carbonate, calcium carbonate and tricalcic phosphate all exert a highly injurious effect upon the growth of lupines. The action of gypsum (calcium sulfate) was injurious, though at first unnoticeable, and subsequently less marked than that of the other calcium compounds. This fact lends some probability to the supposition that the reaction of the soil, so far as concerns acidity or alkalinity, may have played some part in the results. If the differences are due solely or in part to the relative development of the organisms which effect the assimilation of free nitrogen, then it would seem reasonable to attribute the ill effect of lime to its having entered the plant in such quantity as to have rendered it a less suitable medium for the development of these organisms. It may be possible that the presence of lime in considerable quantities within the soil water may exert some external influence, which seems probable in consideration of the greater development of the potato scab upon limed soils. The fact that calcium carbonate is a specific for clover, alfalfa and many other plants upon acid soils where lupines and serradella flourish better before than after liming, indicates, if the varying action of lime on the leguminous plants is explainable upon the basis of the action of these organisms, that there must

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[1] Sixth An. Rpt. R. I. Agrl. Expt. Station, for 1893, p. 232.

[2] Deut. landw. Presse, 1894, No. 88; also Die Boden-Impfung, Bremen, 1896, pp. 79-83.

[3] Mergel and Mergeln, Berlin, 1896, pp. 47-63.

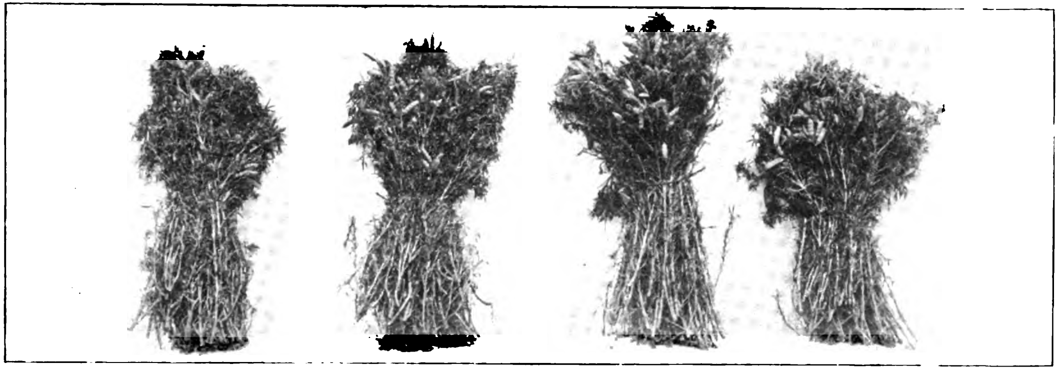

Fig. 12.—Blue Lupine.

Plot 29. *Limed.* Plot 27. *Unlimed.* Plot 25. *Limed.* Plot 23. *Unlimed.*

Nitrate of Soda. Sulfate of Ammonia.

All manured alike with potash and phosphoric acid.

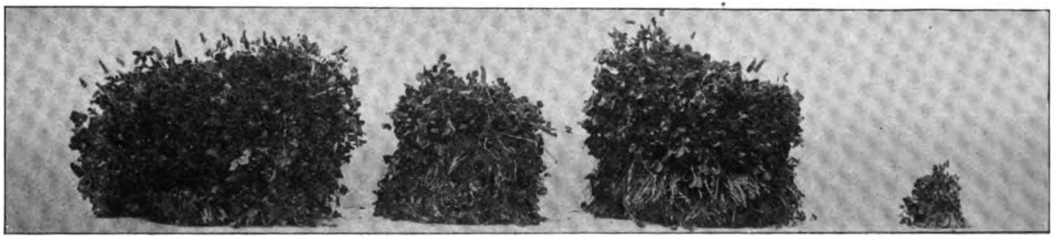

Fig. 18.—Crimson Clover.

Plot 29. *Limed.* Plot 27. *Unlimed.* Plot 25. *Limed.* Plot 23. *Unlimed.*

Nitrate of Soda. Sulfate of Ammonia.

All manured alike with potash and phosphoric acid.

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exist organisms of widely differing character which perform this function in connection with the various leguminous plants, or that, if we have to do with only one organism, its adaptability must have a wide range. It is also noteworthy that favorable conditions for the development of root nodules on lupines, soy beans, and serradella, seem to exist in our acid soil, while clover cannot be grown until lime, or possibly other alkaline substances, are employed.

It is of unusual interest in this connection to note that millet, rye and Indian corn, are likewise injured by applications of air-slacked lime made immediately before the seed is sown or planted, and these plants are not generally supposed to be able to assimilate free nitrogen. The watermelon is likewise most seriously injured by liming, and probably this too belongs, so far as concerns nitrogen assimilation, in the same category.

In these instances some other explanation would seem to be called for, and it may not be improbable that the causes of the ill effect of lime upon these plant may also operate, in a greater or less degree, upon the leguminous plants as well.

Barley. Representing the yield upon the unlimed nitrate of soda plot (27) by 1 pound, the least comparative yield upon the limed plot (29) in any year has been 1.8 pounds, and the maximum 3.71 pounds. On our soil, which contains a large quantity of humus, much of which is in an acid state, barley has been invariably benefited by air-slacked lime, even when the application has almost immediately preceded the sowing of the seed. Upon light, sandy soils, containing but little humus, it would be better, however, to apply the lime the previous autumn, or even a year before, and the amount used at a single application should be much less.

Beets (mangel wurzels). Using the same basis of comparison as for the barley, the increase in the crop of mangel wurzels due to the liming has been, for the four years 1893 to 1896, inclusive, as follows: 7.59, 5.77, 4.95 and 5.73 times. Comparing these results with those secured with barley, it seems reasonable that a soil which is already in such a condition as to be well adapted to barley, might still be greatly benefited by lime in connection with beets, and in fact the co-operative experiments with table beets in various parts of the State, in 1896, confirm very strongly such a view.

In each of the years of the experiment much better results have been secured upon the limed nitrate of soda plot than upon the corresponding sulfate of ammonia plot, but in view of the susceptibility of the beet to injury by soil acidity, it would seem probable that this difference might not be attributable solely to some direct manurial benefit derived from the soda, as assumed by P. Wagner[1] in connection with certain comparative trials of the two forms of nitrogen in Europe, but also perhaps in no inconsiderable degree to the fact that there is left in the soil, in the case of the nitrate of soda, a basic residue, while that from sulfate of ammonia is an acid one. The sulfuric acid would unite with the lime, changing it from calcium carbonate to gypsum (calcium sulfate), by which at least its immediate neutralizing action[2] is destroyed, its solubility increased, and its consequent rapid loss by drainage effected. It is hoped that further experiments may be conducted, in the near future, which will show more definitely to what extent the differences observed are attributable to the one or to the other action.

Crimson clover. The results with crimson clover are in close accord with those secured in 1893, not only showing a marked gain from liming, but better results, under otherwise like conditions, upon the nitrate of soda than upon the sulfate of ammonia plots. (*See illustration, Fig. 13.*)

Carrots. In 1894, the year in which the second annual application of lime was made, there were less carrots upon the limed than upon the unlimed nitrate of soda plot. In view of the fact that in 1893, and in each of the subsequent years, there has been a greater product upon the limed plot, it is possible that the result in 1894 was only incidental. In view of the fact, however, that carrots are much less benefited by liming, and much less subject to injury from soil acidity than beets, it would seem wise to so arrange rotations in which carrots are to be grown that the lime can be applied at least the preceding autumn. This precaution would be more necessary on light and naturally dry sandy soils containing but little humus, than upon heavier ones which are naturally moist.

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[1] Die Stickstoffdüngung, Berlin. 1892, pp. 238-242.

[2] It is claimed that calcium sulfate is sometimes changed to calcium carbonate in soils, though several experiments on our acid soil have failed to show results in accord with such an idea.

Dandelion. In 1894 and 1895 the yield of dandelions was at the rate of 1 pound on the unlimed nitrate of soda plot as compared with 1.6 on the limed one, while it will be seen that the yield upon the limed plot in 1896 represented upon the same basis, amounted to 2.83 pounds. The influence of liming is particularly noticeable upon the first crop in the spring.

Rye. The results with rye with the exception of those for 1895, have shown no injury from liming, and on the other hand, no particular benefit. Representing the yield in 1896 upon the unlimed nitrate of soda plot by one pound, that on the limed plot was 1.38 pounds. These, together with other incidental observations which have been made, indicate that liming should precede if possible by a year or two the cultivation of rye. On very dry, light soils, deficient in humus, this would be particularly true. Rye, common millet, and Indian corn are in these particulars much alike, and they show less benefit from liming than oats, and far less than barley and wheat. Sometimes, and in localities exposed to early frosts, liming might prove of particular value in connection with Indian corn by hastening its maturity.

Spinach. Spinach, as in previous years when it has been grown, has shown a wonderful benefit from liming, and the yield upon the limed nitrate of soda plot has, as heretofore, far exceeded that upon the corresponding one which received sulfate of ammonia. What was said in relation to this marked peculiarity of the beets would probably apply to the spinach, and perhaps to lettuce, another plant which has given analogous results.

Gladiolus. It was very interesting to note that the plants upon the limed plots bloomed considerably in advance of the others, the nitrate of soda plot leading. The last plants to show blossoms, and those which produced the least, were those upon the unlimed sulfate of ammonia plot, which, however, produced the next to the largest weight of bulbs.

EXPERIMENTS WITH SMALL FRUITS, ORCHARD FRUITS, AND FOREST TREES.

In view of the widely varying and sometimes surprisingly beneficial or injurious effects of lime noticed in connection with garden vegetables, cereals and grasses, it was decided to include in the experiment small fruits, orchard fruits, and forest trees, with the expectation that some important data in regard to the effect of lime upon these plants might be obtained, which if not of direct practical application so far as relates to forestry in Rhode Island, might prove of value to nurserymen, and perhaps incidentally to those in charge of parks, and others engaged in beautifying private grounds. A large number of plants are included in this category in regard to which no data are given in the subjoined table. This is for the reason that in two or three instances the plants died to such an extent that they will have to be reset, but in the majority of cases the results obtained will probably be measured by the amount of fruit produced, since that is the chief question involved. This is particularly true of strawberries, raspberries, gooseberries, currants, and grapes. It is not expected that the apple and pear trees can be left upon the plots long enough to produce fruit, owing to the fact that they might disturb some of the crops upon adjoining plots. It may be that for the same reason the quince bushes and peach trees will have to be removed before they are able to produce fruit. On the same account the forest trees can remain but a few years, yet it is hoped that all of these trees can be retained long enough, at least, to furnish data of value to nurserymen, and perhaps also in some instances to fruit growers as well. It would be desirable if an orchard already established could be obtained, where experiments with orchard fruits, already in a bearing condition, could be made.

One or two interesting things were observed in connection with certain of these plants, in the course of the season. In the case of the strawberry plants, one kind, almost without exception, died upon the two sulfate of ammonia plots, while with as few exceptions they lived upon the nitrate of soda plots. The blackberry, on the other hand, acted just the reverse of the strawberry, and apparently grew better upon the unlimed than upon the limed sulfate of ammonia plot. Later in the season potted strawberry plants were set in place of the entire lot which were originally planted, and these were in good condition upon all of the plots upon the advent of winter. The blackberry plants which lived will be removed in the spring of 1897, and all four plots reset under like conditions.

The most marked benefit from lime was noticeable in connection with grape vines (Concord and Delaware), peach and elm trees, and quince bushes. However, these differences were not noticeable until somewhat late in the season, and they would not be expected to become very marked until at least the second or third year.

Wherever it was possible to secure satisfactory results by such means, the diameters of the trees one inch above the level of the ground, and likewise the total length of new growth, have been taken. In the case of each variety the same number of plants has been set upon each plot. In order that an individual record of each one might be made, the following plan was adopted: beginning upon the west side of plot 23 the first plant is numbered 1, and the numbers increase consecutively toward the east. The same plan is followed with plots 25, 27 and 29. It will be obvious, therefore, that there will be four plants of each variety bearing the same number. This explanation seems to be necessary, in order that the tables which follow may be rightly understood:

Table showing the diameter (in centimeters) of the trees and bushes at the beginning and end of the season (1896).

(The plots received like applications of dissolved boneblack, muriate of potash, sulfate of magnesia, and of nitrogen in the specified forms.)

NAME OF TREE.	Tree Number.	SULFATE OF AMMONIA.						NITRATE OF SODA.					
		Plot 23. Unlimed.			Plot 25. Limed.			Plot 27. Unlimed.			Plot 29. Limed.		
		1896.		Increase in Diameter.	1896.		Increase in Diameter.	1896.		Increase in Diameter.	1896.		Increase in Diameter.
		June.	November.		June.	November.		June.	November.		June.	November.	
American White Birch.	1	1.3	1.5	0.2	....	....	....	1.6	1.6	0.0	1.7	1.8	0.1
	2	1.4	1.8	0.4	1.9	1.9	0.0	....	....		1.7	2.0	0.3
	3	1.4	1.5	0.1	...	....	..	1.1	1.4	0.3	2.1	2.3	0.2
	4	....	....	....	1.4	1.5	0.1	....	..	....	....	....	....
	5	1.2	1.4	0.2	....	...	....	1.2	1.3	0.1	1.8	1.9	0.1
	6	....	...	..	1.6	1.8	0.2	....	....	....	....	....	....
	7	1.4	1.6	0.2	1.4	1.5	0.1	1.5	1.7	0.2	....	....	...
	8	...	....	...	2.0	2.3	0.3	1.7	1.9	0.2	....	....	....
	9	....	....	...	1.7	1.7	0.0	..	...	....	1.6	1.7	0.1
	10	....	....	..	....	....	....	1.9	1.9	0.0	1.9	1.9	0.0
Total	....	6.7	7.8	1.1	10.0	10.7	0.7	9.0	9.8	0.8	10.8	11 6	0.8
Average.........	....	1.4	1.6	0.2	1.7	1.8	0.1	1.5	1.6	0.1	1.8	1.8	0 1
American Elm.	1	1.5	2.0	0.5	1.5	2.1	0.6	2.8	2.9	0.1	1.5	2.5	1.0
	2	1.5	1.8	0.3	1.6	2.5	0.9	2.2	2.6	0.4	2.5	2.8	0.3
	3	1.8	1.9	0.1	1.4	1.8	0.4	1.7	2.0	0.3	1.8	2.6	0.8
	4	1.7	1.9	0.2	2.6	3.0	0.4	1.8	2.3	0.5	1.9	2.8	0.9
	5	1.7	2.1	0.4	1.9	2.4	0.5	1.7	2.0	0.3	1.9	2.4	0.5
	6	1.9	2.3	0.4	1.4	2.1	0.7	2.0	2.9	0.9	2.3	2.3	0.0
	7	1.7	1.7	0.0	2.0	2.5	0.5	1.7	2.3	0.6	1.6	2.2	0.6
	8	1.7	2.4	0.7	2.0	2.4	0.4	1.5	1.9	0.4	1.4	2.0	0.6
	9	1.7	2.3	0.6	1.6	2.2	0.6	1.9	2.5	0.6	1.7	2.6	0.9
Total	....	5.2	18.4	3.2	6.0	21.0	5.0	17.3	21.4	4.1	16.6	22.2	5.6
Average....	....	1.7	2.0	0.3	1.8	2.3	0.5	1.9	2.4	0.5	1.9	2.5	0.6

Table showing the diameters (in centimeters) of the trees and bushes at the beginning and end of the season (1896).

(The plots received like applications of dissolved boneblack, muriate of potash, sulfate of magnesia, and of nitrogen in the specified forms.)

NAME OF TREE.	Tree Number.	SULFATE OF AMMONIA.						NITRATE OF SODA.					
		Plot 23. Unlimed.			Plot 25. Limed.			Plot 27 Unlimed.			Plot 29. Limed.		
		1896. June.	1896. November.	Increase in Diameter.	1896. June.	1896. November.	Increase in Diameter.	1896. June.	1896. November.	Increase in Diameter.	1896. June.	1896. November.	Increase in Diameter.
Sugar Maple.	1	0.9	1.1	0.2	0.9	1.0	0.1	...	....	....	0.7	0.8	0.1
	2	1.1	1.2	0.1	...	....	....	1.0	1.2	0.2	0.9	0.9	0.0
	3	0.8	1.2	0.4	0.9	0.9	0.0	0.7	0.9	0.2	0.8	0.8	0.0
	4	1.0	1.1	0.1	....	....	....	0.9	1.0	0.1	1.0	1.2	0.2
	5	0.9	1.1	0.2	0.9	1.0	0.1	0.8	1.0	0.2	1.0	1.2	0.2
	6	1.0	1.3	0.3	0.9	1.1	0.2	...	..	....	1.0	1.2	0.2
	7	1.0	1.1	0.1	..	..	..	0.7	0.7	0.0	1.1	1.3	0.2
	8	1.0	1.1	0.1	0.8	0.9	0.1	0.8	1.1	0.3	1.0	1.1	0.1
	9	0.9	0.9	0.0	0.6	0.7	0.1	0.9	1.2	0.3	1.3	1.3	0.0
Total...........	....	8.6	10.1	1.5	5.0	5.6	0.6	5.8	7.1	1.3	8.8	9.8	1.0
Average.........	....	0.9	1.1	0.2	0.8	0.9	0.1	0.8	1.0	0.2	1.0	1.1	0.1
Orange Quince.	1	1.3	1.4	0.1	1.7	1.9	0.2	1.1	1.8	0.7	1.2	1.8	0.6
	2	1.0	1.2	0.2	1.2	1.8	0.6	1.0	1.7	0.7	1.0	1.7	0.7
	3	0.9	1.0	0.1	0.9	1.7	0.8	1.0	1.7	0.7	1.2	1.8	0.6
	4	1.1	1.3	0.2	1.4	2.0	0.6	1.5	1.5	0.0	1.1	1.6	0.5
	5	1.2	2.0	0.8	1.2	1.8	0.6	1.2	1.7	0.5	1.0	1.4	0.4
Total...........	....	5.5	6.9	1.4	6.4	9.2	2.8	5.8	8.4	2.6	5.5	8.3	2.8
Average.........	...	1.1	1.4	0.3	1.3	1.9	0.6	1.2	1.7	0.5	1.1	1.7	0.6
Bartlett Pear.	1	0.9	1.0	0.1	1.1	1.2	0.1	0.8	1.1	0.3	1.1	1.4	0.3
	2	1.1	1.5	0.4	0.8	1.2	0.4	1.1	1.6	0.5	0.8	1.2	0.4
	3	1.0	1.3	0.3	0.8	1.3	0.5	1.1	1.7	0.6	1.0	1.4	0.4
	4	1.2	1.5	0.3	1.0	1.7	0.7	0.9	1.4	0.5	1.1	1.4	0.3
	5	1.1	1.5	0.4	0.9	1.2	0.3	0.9	1.1	0.2	0.9	1.2	0.3
Total...........	....	5.3	6.8	1.5	4.6	6.6	2.0	4.8	6.9	2.1	4.9	6.6	1.7
Average.........	....	1.1	1.4	0.3	0.9	1.3	0.4	1.0	1.4	0.4	1.0	1.3	0.3

Table showing the diameters (in centimeters) of the trees and bushes at the beginning and end of the season (1896).

(The plots received like applications of dissolved boneblack, muriate of potash, sulfate of magnesia, and of nitrogen in the specified forms.)

NAME OF TREE.	Tree Number.	SULFATE OF AMMONIA.						NITRATE OF SODA.					
		Plot 23. Unlimed.			Plot 25. Limed.			Plot 27. Unlimed.			Plot 29. Limed.		
		1896.		Increase in Diameter.	1896.		Increase in Diameter.	1896.		Increase in Diameter.	1896.		Increase in Diameter.
		June.	November.		June.	November.		June.	November.		June.	November.	
Early Crawford Peach.	1	1.8	2.1	0.3	2.1	3.1	1.0	2.1	2.7	0.6	1.4	2.5	1.1
	2	1.9	1.9	0.0	1.7	2.8	1.1	1.6	2.7	1.1	1.8	2.4	0.6
	3	1.6	2.4	0.8	1.5	2.2	0.7	1.6	2.5	0 9	1.6	2.6	1.0
	4	2.0	2.5	0.5	1.8	2.5	0.7	1.9	2.2	0.3	1.7	2.5	0.8
	5	2.0	2.6	0.6	2.1	2.7	0.6	1.6	2.0	0.4	1.8	2.7	0.9
Total....	....	9.3	11.5	2.2	9.2	13.3	4.1	8.8	12.1	3.3	8.3	12.7	4.4
Average.........	...	1.9	2.3	0.4	1.9	2.7	0.8	1.7	2.4	0.7	1.6	2.5	0.9
Golden Sweet Apple.	1	1.3	1.7	0.4	1.5	1.7	0.2	1.4	1.9	0.5	1.6	2.4	0.8
	2	1.3	1.8	0.5	1.3	1.5	0.2	1.3	1.7	0.4	1.6	2.3	0.7
	3	1.5	2.0	0.5	1.3	1.7	0.4	1.3	1.7	0.4	1.5	1.9	0.4
	4	1.6	1.7	0.1	1.3	1.8	0.5	1.5	1.8	0.3	1.6	2.1	0.5
	5	1.4	1.8	0.4	1.2	1.8	0.6	1.4	1.7	0.3	1.2	1.6	0.4
Total............	....	7.1	9.0	1.9	6.6	8.5	1.9	6.9	8.8	1.9	7.5	10.3	2.8
Average.........	....	1.4	1.8	0.4	1.3	1.7	0.4	1.4	1.8	0.4	1.5	2.1	0.6
Baldwin Apple.	1	1.3	1.8	0.5	1.3	1.9	0.6	1.1	1.8	0.7	1.2	1.8	0.6
	2	1.3	1.8	0.5	1.2	1.7	0.5	1.1	1.8	0.7	1.3	1.8	0.5
	3	1.1	1.5	0.4	1.4	2.0	0.6	1.2	1.9	0.7	1.3	1.9	0.6
	4	1.6	2.0	0.4	1.4	1.6	0.2	1.1	1.9	0.8	1.2	1.5	0.3
	5	1.4	2.1	0.7	1.3	2.0	0.7	1.4	1.9	0.5	1.4	2.0	0.6
Total.	....	6.7	9.2	2.5	6.6	9.2	2.6	5.9	9.3	3.4	6.4	9.0	2.6
Average.........	....	1.3	1.8	0.5	1.3	1.8	0.5	1 2	1.9	0.7	1.3	1.8	0.5

Table showing the total length (in inches) of new growth produced during 1896.

(The plots received like applications of dissolved boneblack, muriate of potash, sulfate of magnesia, and of nitrogen in the specified forms).

NAME OF PLANT.	Plant Number.	SULFATE OF AMMONIA.				NITRATE OF SODA.			
		Plot 23. Unlimed.		Plot 25. Limed.		Plot 27. Unlimed.		Plot 29. Limed.	
		Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.
American White Birch.	1	19	150.00	....	....	37	133.75	18	140.25
	2	36	347.00	23	49.50	...	....	25	180.50
	3	18	61 50	...	....	15	113.75	29	238.00
	4	....	....	29	146.75		....	....	....
	5	20	197.75	...	....	15	106.75	30	69.00
	6	....	.. ....	21	140.50	....	....	...	....
	7	15	110 00	17	32.50	24	243.00	....	... .
	8	..	....	26	136.00	16	155.25	....	....
	9	....	....	19	147 00	...	....	25	164.25
	10	....	....	...	....	6	25.25	18	104.75
Total............	....	....	866.25	....	652.25	...	777.75	....	896.75
Average....	....	...	173.25	....	108.71	....	129.63	...	149.46
American Linden.	1	2	31.00	7	76.50	5	17 50	3	4.50
	2	6	32.75	8	54.75	4	53.50	5	16.00
	3	6	21.25	5	61.50	10	28.25	7	39.00
	4	3	26.00	4	96 75	6	17.25	5	9.25
	5	2	24.25	4	18.50	7	26.25	6	15 00
	6	8	41.00	4	24.00	3	19.00	4	17.25
	7	4	35.75	6	54.50	8	36 00	3	25.75
	8	4	30.50	8	68.75	6	23.25	3	31.25
	9	3	41.00	7	61.00	9	33 25	8	61.75
Total.............	....	....	283.50	....	516.25	....	254.25	....	219.75
Average.	....	....	31.50	....	57.36	....	28.25	....	24.42

Table showing the total length (in inches) of new growth produced during 1896.

(The plots received like applications of dissolved boneblack, muriate of potash, sulfate of magnesia, and of nitrogen in the specified forms).

NAME OF PLANT.	Plant Number.	SULFATE OF AMMONIA.				NITRATE OF SODA.			
		Plot 23. Unlimed.		Plot 25. Limed.		Plot 27. Unlimed.		Plot 29. Limed.	
		Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.
American Elm.	1	16	201.00	10	159.25	72	457.25	15	269.00
	2	16	189.50	18	273.25	17	171.50	23	328.25
	3	12	75.25	22	202.00	21	294.00	16	153.00
	4	27	228 50	19	216.25	25	185.25	22	228.75
	5	14	117.25	26	283.50	43	112.75	8	148.50
	6	30	222.75	19	186.75	35	288.50	17	305.75
	7	8	62.75	47	335.50	10	198.75	36	233.50
	8	9	139.25	20	245.50	15	124.25	21	414.25
	9	47	409.75	36	293.00	15	399.25	87	560.25
Total	....	....	1646 00	...	2195.00	....	2231 50	..	2641.25
Average	....	....	182 89	....	243.89	....	247 94	...	293 47
Sugar Maple.	1	6	18.00	6	11.75	..	....	8	15 75
	2	4	7.25	....	....	5	19.50	7	15.75
	3	6	9.25	8	6.25	4	13.00	2	1.25
	4	8	10.00	....	....	8	6.00	5	9.50
	5	7	9.00	3	6.25	8	16.75	8	12 25
	6	6	9.50	3	3.25	....	....	10	28.25
	7	8	6.00	....	....	3	5.00	6	14.25
	8	8	10.00	5	9.75	6	7.25	8	7.75
	9	4	3.50	7	7.25	7	9.25	8	8.75
Total	....	....	82.50	....	44.50	....	76.75	..	113.50
Average	....	....	9.17	....	7 42	....	10.96	....	12.61
Orange Quince.	1	14	91.75	15	254.75	16	194.75	20	193.25
	2	8	69.50	6	101.50	9	120.75	11	131.50
	3	18	43.75	7	155.00	12	172.75	13	191 25
	4	12	75.50	29	126.50	12	89 25	10	156.50
	5	18	112.25	16	256.50	9	179.00	8	100.25
Total	....	....	392.75	....	894.25	....	756.50	...	772 75
Average	....	...	78.55	....	178.85	...	151.30	....	154 55

Table showing the total length (in inches) of new growth produced during 1896.

(The plots received like applications of dissolved boneblack, muriate of potash, sulfate of magnesia, and of nitrogen in the specified forms).

NAME OF PLANT.	Plant Number.	SULFATE OF AMMONIA.				NITRATE OF SODA.			
		Plot 23. Unlimed.		Plot 25. Limed.		Plot 27. Unlimed.		Plot 29. Limed.	
		Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.
Bartlett Pear.	1	3	15.50	5	32.25	7	32.50	8	26.00
	2	6	49.50	8	68.00	10	106.25	8	37.75
	3	4	66.75	4	51.50	3	41.00	5	42.75
	4	2	26.75	8	77.50	3	39.25	3	42.50
	5	5	60.25	2	22.50	3	14.50	2	38.00
Total	....	....	218.75	....	251.75	...	233.50	....	187.00
Average	...	....	43.75	....	50.35	....	46.70	....	37.40
Crawford's Early Peach.	1	21	172.00	70	865.00	81	601.00	47	472.75
	2	12	150.00	64	695.25	54	591.50	48	365.25
	3	54	506.50	62	451.25	59	591.75	45	485.50
	4	66	533.00	48	403.75	26	209.00	48	431.25
	5	34	262.75	56	528.75	41	279.00	78	686.50
Total	....	....	1624.25	...	2944.00	....	2272.25	....	2441.25
Average	....	...	324.85	....	588.80	...	454.45	....	488.25
Golden Sweet Apple.	1	2	52.00	3	35.50	3	101.00	6	114.25
	2	6	70.50	3	26.50	3	72.75	12	139.75
	3	4	95.00	4	66.00	4	59.50	6	89.50
	4	2	15.75	10	103.00	5	102.50	3	93.50
	5	5	107.50	7	105.50	5	85.50	2	46.75
Total	....	....	340.75	....	336.50	....	421.25	....	483.75
Average	....	....	68.15	...	67.30	...	84.25	....	96.75
Baldwin Apple.	1	6	81.25	3	76.50	6	73.00	6	25.25
	2	7	88.25	5	69.00	4	92.25	3	67.00
	3	5	40.50	3	75.25	7	71.50	4	72.75
	4	3	76.25	3	30.50	5	117.00	5	36.00
	5	7	122.25	6	124.25	4	105.25	10	186.50
Total	..	....	408.50	....	375.50	....	459.00	....	387.50
Average	....	..	81.70	....	75.10	....	91.80	....	77.50

Table showing the total length (in inches) of new growth produced during 1896.

(The plots received like applications of dissolved boneblack, muriate of potash, sulfate of magnesia, and of nitrogen in the specified forms).

NAME OF PLANT.	Plant Number.	Sulfate of Ammonia.				Nitrate of Soda.			
		Plot 23. Unlimed.		Plot 25. Limed.		Plot 27. Unlimed.		Plot 29. Limed.	
		Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.
Delaware Grape.	1	1	15.25	1	1.50	1	3.50	13	245.00
	2	4	55.00	1	23.75	7	52.00	8	146.00
	3	3	24.25	9	70.50	4	67.00	7	85.00
	4	1	12.00	8	133.50	8	90.00	10	125.00
	5	2	28.00	5	69.00	4	34.50	5	54.00
Total	....	....	134.50	....	298.25	..	247.00	....	655.00
Average	....	....	26.90	....	59.65	....	49.40	....	131.00
Concord Grape.	1	6	43.50	5	58.00	10	109.50	4	57.00
	2	3	45.00	5	51.00	11	161.50	7	105.00
	3	5	37.00	5	87.00	5	69.50	12	193.00
	4	4	48.00	8	65.00	15	179.50	8	131.00
	5	6	58.00	9	198.00	8	113.00	13	170.00
Total	....	....	331.50	..	459.00	....	633.00	....	656.00
Average	....	....	46.30	....	91.80	....	126.60	....	131.20
White Dutch Currant.	1	....	....	4	12.75	....	......	....	....
	2	....	....	7	30.75	....	......	....	....
	3	4	8.00	....	....	....	....	5	23.75
	4	..	....	5	23.75	8	67.75	....	....
	5	....	....	3	10.50	3	12.50	4	16.50
	6	...	....	....	......	....	....	4	20.50
	7	11	68 00	4	34.75	6	20.00	4	41.00
	8	....	....	1	7.00	....	....	5	60.25
	9	10	30.50	....	....	10	58.50	4	10.50
	10	5	20.50	5	50.75	6	70.00	....	....
Total	....	....	127.00	....	170.25	....	228.75	....	172.50
Average	..	...	31.75	....	24 32	....	45.75	....	28.75

Table showing the total length (in inches) of new growth produced during 1896.

(The plots received like applications of dissolved boneblack, muriate of potash, sulfate of magnesia, and of nitrogen in the specified forms).

NAME OF PLANT.	Plant Number.	SULFATE OF AMMONIA.				NITRATE OF SODA.			
		Plot 23. Unlimed.		Plot 25. Limed.		Plot 27. Unlimed.		Plot 29. Limed.	
		Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.	Number of Branches.	Length of New Growth.
Fay's Improved Currant.	1	10	39.50	....	....	10	61.50	6	17.00
	2	....	....	....	....	5	28.25	7	34.25
	3	6	25 25	7	30.25	4	7.00	5	28 25
	4	7	46.50	6	8.00	7	18 75	12	47.25
	5	5	9.00	9	36.25	6	36.25	8	27 00
	6	....	....	5	5.75	8	39.00	7	56.00
	7	....	....	5	6.00	7	30.25	7	37.75
	8	7	28.75	....	... ...	8	23.75	....	....
	9	5	12.00	4	4.75	....	... .	. .	... .
	10	7	34.00	11	48.75	5	21.50	7	40.75
Total..............	....	...	195.00	....	139.75	....	266.25	....	288.25
Average...........	....	....	27.86	....	19.96	....	29.58	...	36.03

SUMMARY.

1. The experiments with grasses show that they vary almost as widely as other plants, so far as concerns the effect of lime upon them.

2. Of the grasses tested, Kentucky blue grass and timothy seem to be most benefited by liming, and Rhode Island bent and red top most indifferent to it.

3. Awnless brome grass, meadow oat grass, tall fescue and orchard grass, which are among the most promising of the other grasses tried, all show decided benefit from liming.

4. These results serve to explain why, on many of our Rhode

Island soils, timothy "runs out" quickly, and red top and Rhode Island bent persist better.

5. Without doubt many failures of timothy attributable to poor seed, or failure to "catch" without definitely known cause, could have been prevented had the land been adequately provided with lime in the form of slacked lime or wood ashes.

6. One of the miscellaneous plants which has shown an injury from lime applied shortly before it has been grown, and which has failed to be benefited by it after it had lain in the soil long enough to lose its caustic property, is the lupine, but this plant has never been grown to any extent in Rhode Island.

7. The watermelon seems thus far to be about the only plant which is frequently grown here which may not be benefited eventually by liming. It is hoped, however, in succeeding years to test this plant more fully.

8. Potatoes have sometimes produced a slightly greater total yield from liming, and usually a much greater percentage of merchantable tubers, but owing to the fact that wood ashes and water—or air-slacked lime (not gypsum or land plaster) increase the virulence of the potato scab to a serious degree, lime in these forms, if used at all on potato fields, should be applied in small quantities, seldom exceeding half a ton per acre. The seed tubers should also be as free as possible from the scab, and be treated with corrosive sublimate solution, or with formalin,[1] the new remedy tried successfully by the Indiana Experiment Station in 1896.

9. Since potatoes, Indian corn, rye, Rhode Island bent grass and red top are less in need of lime than timothy, clover, barley, etc., certain fields could be set aside for rotations without lime and others with it.

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[1] See end of this summary for a description of the method of treating potato tubers with corrosive sublimate and with formalin.

10. Beets have shown a wonderful benefit from liming, not only on the Station farm but in many other sections of the State where experiments with them have been tried.

11. Spinach has again shown great benefit from liming, it being in this particular like lettuce.

12. Rye, dandelions (excepting the first crop in the spring), carrots and crimson clover have shown a less marked benefit from liming than beets and spinach.

13. Lupines, which are grown so extensively for green manuring in Germany, but which are unsafe as feed until a poisonous substance has been extracted from them, are seriously injured by liming.

14. In regard to small fruits, orchard fruits and forest trees, little can be said at this time except that grapes (particularly the Delaware), peach and elm trees and quince bushes, seem to be benefited by liming. Blackberries were apparently very thrifty on the unlimed sulfate of ammonia plot, where many plants are wholly unable to endure the soil conditions.

Methods of treatment of seed tubers prior to planting, for the purpose of preventing or lessening the potato scab.

If soils are already badly contaminated, and are favorable to the scab by reason of alkalinity, or the previous use of much stable manure, lime or wood ashes, the following methods of treatment are ineffectual:

Formalin had already been shown to be a powerful antiseptic, but Dr. Arthur seems to have been the first to test its efficacy in combating the potato scab. As he states, it is not very expensive, and can be bought by the fluid ounce at most drug stores. The following is his description of the method of treatment, in regard to which further information will be given in a bulletin of the Indiana Experiment Station:

FORMALIN TREATMENT.

"The method of using the new fungicide is very simple. Eight ounces of the formalin are added to 15 gallons of water, and in this the seed potatoes are soaked for two hours. After taking from the bath they can be cut and planted as usual, either at once or after some time. Formalin is not corrosive, and so can be used in any kind of vessel, and not being poisonous, there are no particular precautions to be observed. It does, however, make the hands smart, if there are any raw spots, and the fumes irritate the eyes and throat. But these are only slight annoyances."

CORROSIVE SUBLIMATE TREATMENT.

The directions for the use of Bolley's corrosive sublimate treatment, already described in Bulletin 26, of this Station, are as follows:

Corrosive sublimate can be bought at drug stores in the form of crystals. Two and one-fourth ounces of these crystals should be dissolved in a few gallons of hot water, and enough cold water added to make fifteen gallons of solution; the whole should then be well stirred. In preparing the solution and treating the seed, use wooden vessels only. Two barrels with wooden faucets are convenient, the solution being drawn from one to the other whenever it is desired to remove the potatoes. The potatoes may also be put in a sack and dipped into the solution. The same solution may be used repeatedly. The whole tubers after first being washed should be placed in the solution for one and a half hours, then spread out to dry and cut and planted as usual. This solution is extremely poisonous, and should not be allowed to get into the mouth, nor into wells, springs, etc., nor be left where animals can gain access to it.

CONTINUED OBSERVATIONS FOR THE PURPOSE OF DETERMINING IN HOW FAR THE RESULTS SECURED IN A SOIL TEST WITH A GIVEN PLANT ARE APPLICABLE TO OTHERS.

H. J. WHEELER AND G. M. TUCKER.

This experiment was conducted upon plots which have been employed in the same connection continuously since 1890. During the first four years, 1890 to 1893, inclusive, Indian corn was the only plant employed in the trial. The first year of the trial, potash seemed to be more deficient than phosphoric acid. The first crop, however, appeared to have exhausted the supply of assimilable phosphoric acid, for the second and each succeeding crop gave marked indications of a greater deficiency of phosphoric acid than of potash or nitrogen. The details of the first four years' experiments with Indian corn may be found in the Annual Reports of this Station for 1890, 1891, 1892 and 1893, under the heading "Co-operative Field Experiments with Indian Corn." In 1894, 37 varieties of plants were employed, all but three of which, namely, the white bean, sunflower and summer squash, indicated a greater deficiency of phosphoric acid than of potash, while these three indicated that potash was more deficient than phosphoric acid. In 1894 but two rows of each kind of plants were introduced into the experiment. This was done merely on account of lack of space, it being desirable to secure indications with as many plants as possible, upon which more extended observations could be based in the future. In 1895 but ten varieties of plants were employed, among which were included those with somewhat questionable soil requirements, the crimson clover, white bean, sunflower, and two varieties of squashes. (The other plants introduced were such as had shown, in 1894, an unquestionable lack of assimilable phosphoric acid.) A number of rows of each were employed. Owing to an accidental interchange by some one of the fertilizers intended for plots 4 and 5, the results secured in 1895 had to be discarded, with the exception of those from plots 1, 2 and 3, upon which nitrogen, phosphoric acid and potash were applied singly. The indications afforded by the last mentioned plots were to the effect that phosphoric acid was more deficient than potash, yet considered by themselves and with exclusion of the results from plots 4, 5 and 6, they could be looked upon merely as indicative and not as conclusive. In order to further test this question the experiment has been continued, in 1896, with the sunflower, white bean, crimson clover and the following crops,[1] which had heretofore invariably shown a deficiency of phosphoric acid, namely: Indian corn, millet, and spring rye. The results are embodied in the following table.

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[1] Squashes were likewise included, but they proved a total failure, and consequently no results were obtained from them this season.

Table Showing the Weights of Various Crops (in pounds) upon the Soil Test Plots in 1896.

NAME OF CROPS.	PLOT 1.		PLOT 2.		PLOT 3.		PLOT 4.		PLOT 5.		PLOT 6.		PLOT 7.	
	Nitrate of Soda, 24 lbs.		Diss. Bone-black, 80 lbs.		Muriate of Potash, 10 lbs.		Nitrate of Soda, 24 lbs., Diss. Bone-black, 80 lbs.		Nitrate of Soda, 24 lbs., Muriate of Potash, 10 lbs.		Diss. Bone-black, 80 lbs., Muriate of Potash, 10 lbs.		Nitrate of Soda, 24 lbs., Diss. Bone-black, 80 lbs., Muriate of Potash, 10 lbs.	
	North and south rows.	Average of rows.	North and south rows.	Average of rows.	North and south rows.	Average of rows.	North and south rows.	Average of rows.	North and south rows.	Average of rows.	North and south rows.	Average of rows.	North and south rows.	Average of rows.
Sunflower[1]	17.0 11.8	14.4	24.5 8.0	16.3	53.3 22.0	37.7	80.8 85.5	83.2	67.8 77 5	72.7	165.0 136.0	150.5	163.0 170.3	166.7
White bean[2]	0.6 *	.....	1.0 *	......	0.1 *	......	0.7 *	.....	0.2 *	......	0.5 *	.....	0.7 *	......
Crimson clover[1]	15.2 7.5	11.4	11.7 7.8	9.8	13.0 9.3	11.2	25 8 28.0	26.9	23.0 17.0	20.0	20.7 18.5	19.6	33.8 32.0	32.9
Golden millet[1]	12.6 9.5	11.1	14.8 22.3	18 6	13.6 6.0	9.8	33.5 28.8	31.2	20.3 28.5	24.4	43.3 51.8	47.6	53.1 56.8	55.0
Indian corn (stover)[2]	3.0 3.3	3.2	3.8 7.5	5.7	3.3 4.0	3.7	7.0 11.5	9.3	5.5 8.3	6.9	9.8 14.8	12.3	9.3 13.5	11.4
Indian corn (ears)[2]	2.0 2.3	2.2	2.5 7.0	4.8	2.3 2.3	2.3	9.0 11 0	10.0	6.0 7.0	6.5	10.8 13.8	12.3	11.5 10.3	10.9
Spring rye[1]	0.4 0 6	0.5	0.8 1 6	1.2	0.7 1.0	0.9	2.2 2.7	2.5	1.2 1.9	1.6	3.3 4.9	4.1	3.3 4.7	4.0
White bean (vines and beans)[2]	1.8 1.3	1.6	1.5 1 0	1.3	2.3 2.5	2.4	6.0 6.0	6.0	5.3 7.8	6.6	7.0 7.8	7.4	7.3 7.5	7.4

* Not weighed.

[1] Weighed immediately upon cutting.

[2] After drying in the field.

In connection with the plots where the three ingredients were employed singly (1, 2 and 3), crimson clover produced a greater yield in the case of the north rows, upon both plots 1 and 3, than upon plot 2, where phosphoric acid was used. In the case of the rows upon the south sections of the plots, there was little difference between the yields upon the nitrogen and phosphoric acid plots, and that upon the potash plot (3) was greatest of all. In the case of the sunflower, the greatest yields were obtained upon the potash plot in the case of both the north and south rows, while with the other plants employed there was little or no difference, or else the yields upon the phosphoric acid plot were greater than upon either of the other two. In connection with combinations of two ingredients (plots 4, 5 and 6), crimson clover showed, in the case of the north rows, a greater yield upon the nitrogen and potash plot than upon the one which received potash and phosphoric acid, while the greatest yield was obtained upon the one receiving phosphoric acid and nitrogen. This, taken in connection with the results upon the plots receiving the single ingredients, shows the apparent dependence of the clover, on this particular soil, upon a considerable supply of readily assimilable nitrogen; and since nitrogen and phosphoric acid gave better yields than nitrogen and potash, in the case of both the north and south rows, it will be seen that this plant does not, from this year's results, appear so well calculated to tell the requirements of soils for phosphoric acid as many others. It is interesting to note that the sunflower, upon both the north and south rows, gave greater yields in connection with nitrogen and phosphoric acid than in connection with nitrogen and potash. According to the evidence afforded by the sunflower upon these three plots, the ingredient chiefly deficient in the soil would be considered as phosphoric acid, followed by potash and nitrogen respectively. Comparing the results upon these plots with those obtained upon plots 1, 2 and 3, it will be seen that the conclusions which might have been drawn from the use of single elements, and from the use of combinations of two elements, would be very much in contrast with each other, yet for reasons which it is perhaps unnecessary to discuss here, the indications in connection with a combination of the two elements are doubtless more reliable than those obtained where the elements are employed singly. The results with white beans, owing to their very limited growth, are wholly inconclusive. In the case of the other crops employed in this trial, they seem to show, like the Indian corn and most other plants tried in the past, that the soil is chiefly deficient in phosphoric acid, followed by potash and nitrogen respectively.

SUMMARY.

The results of the experiment this season with the sunflower indicate that the soil was chiefly deficient in phosphoric acid, followed by potash and nitrogen respectively, or in other words, was practically in accord with results secured with other plants in previous years. Crimson clover, from this year's indications, as well as from those of the two previous years, does not seem to be so well adapted as many other plants for determining the soil requirements, so far as concerns phosphoric acid. The results of the three years indicate that out of the thirty-five plants employed in this soil test (excepting possibly crimson clover, white beans, sunflowers and squashes), almost any one of them would have answered in a satisfactory manner the question as to what element was chiefly deficient in this soil. It may, perhaps, be shown upon further and more extended trial, that the sunflower in most cases, and even the white bean, crimson clover and squashes, might indicate the same soil requirements as are exhibited by most other plants, yet in view of the fact that the indications afforded by them in relation to phosphoric acid are liable to be uncertain, and are less marked than those exhibited by the other plants experimented with, it would seem desirable, in testing a soil as to deficiencies of phosphoric acid, to leave these plants out of consideration. They might, however, in a more extended trial upon a soil very deficient in potash or nitrogen, prove to be the most desirable plants that could be employed for determining deficiencies of those ingredients in soils; yet in view of the fact that leguminous plants are liable to find within the soil organisms by which they are enabled to take their nitrogen from the air, it would not be safe, of course, to look upon crimson clover as a plant capable of giving sure indications of deficiencies of assimilable nitrogen.

FURTHER OBSERVATIONS UPON THE GROWTH OF BARLEY UPON AN ACID UPLAND SOIL, LIMED AND UNLIMED.

H. J. WHEELER AND G. M. TUCKER.

In the observations heretofore made upon the growth of barley upon an acid soil, limed and unlimed, data were secured from single rows of barley, which had been planted across plots 23, 25, 27 and 29. In these experiments the total weights of grain and straw were secured, the amount of material at disposal not being sufficiently great to make a separation of straw and grain of particular value. The results given in this connection have been secured upon certain of the plots of the so-called co-operative acre referred to in each of the previous Annual Reports of this Station, excepting the first and second. These plots had been seeded in the fall of 1895 with mixed grass seed for the purpose of making observations upon the relative permanency of various grasses upon an acid soil, limed and unlimed. However, the grass failed to catch, and an opportunity was thus afforded for the trial of barley upon these plots. Unfortunately, the stand of barley was so light that the land became seriously infested with weeds, owing to which it was impossible to harvest the barley in such a way as to obtain the weight of straw independent of the weeds, without a great outlay of time and labor in assorting the material. It was decided to allow the barley to ripen, and thus secure the weight of the grain without attempting to separate the straw from the weeds. The weights obtained are given in the subjoined table. It will be seen that data have been secured from the plots which had received no nitrogen whatever for a long period of years, also from those which had received annual applications of dried blood in one-third, two-thirds and full rations, and likewise from those receiving one-third, two-thirds and full rations of sulfate of ammonia, and two-thirds and full rations of nitrate of soda.

Table Showing Weights per Acre of Barley (Grain) upon Limed and Unlimed Soil.

Unmanured since 1894. For diagram of plots see Annual Report for 1894, p. 112.
The limed sections of the plots received but one application of air-slacked
lime, which was in 1893, at the rate of 2½ tons per acre.

NUMBERS OF PLOTS.	LIMED. Pounds of Grain.	UNLIMED. Pounds of Grain.
*Plots without nitrogen.**		
No. 6a, without nitrogen, located between Nos. 9 and 10...	195.0	22.5
No. 6b, “ “ “ “ “ 12 “ 13...	210.0	67.5
No. 6c, “ “ “ beside No. 15....	150.0	52.5
Average of 6a, 6b and 6c	*185.0*	*47.5*
*Plots manured previously with dried blood.**		
No. 13, 86⅔ lbs. dried blood	195.0	75.0
No. 14, 173⅓ “ “ “	270.0	75.0
No. 15, 260 “ “ “	285.0	30.0
*Plots manured previously with sulfate of ammonia.**		
No. 10, 40 lbs. sulfate of ammonia..........	180.0	30.0
No. 11, 80 “ “ “ “	195.0	30.0
No. 12, 120 “ “ “ “	195.0	30.0
*Plots manured previously with nitrate of soda.**		
No. 8, 106⅔ lbs. nitrate of soda..........	180.0	67.5
No. 9, 160 “ “ “ “	195.0	45.0

It is interesting to note that the yields upon the limed sections of the plots, even where no nitrogen had been applied for years, were very good, as compared with those upon the corresponding sections of the plots where nitrogen in the form of dried blood, sulfate of ammonia and nitrate of soda, had been used annually for several seasons. The plots were somewhat irregular, and the yields in the past have not been as uniform as might have been desired, which is due, probably, to a considerable extent, to a depression which runs across these plots. Owing to this disturbing factor, no attempt will be made here to make any strict comparisons between the yields from the different forms of nitrogen applied previously, except perhaps to point out that the greatest yields were obtained upon those plots which had continually received nitrogen in the form of dried blood. The better results upon these plots, as compared with those where sulfate of ammonia and nitrate of soda had been used, may be attributable to the accumulation of nitrogen from the applications of preceding years, in the first instance, and to the leaching away of the nitrogen compounds in the other cases.

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* Each had also been manured previously with dissolved boneblack and muriate of potash.

The chief point of interest in connection with this experiment is the effect upon the yield of barley (grain) produced by liming, which as will be seen by a study of the above table is enormous. It appears, therefore, that the results secured with single rows of barley in another experiment have not been incidental, but were truly indicative of what would result under similar circumstances upon larger areas.

SUMMARY.

In brief, the foregoing experiment proves conclusively the correctness of the observations made in previous experiments[1] to the effect that on a decidedly acid soil barley may be wonderfully benefited by liming.

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[1] See Sixth An. Rep. of this Station, 1893, pp. 246-248; Seventh An. Rep. for 1894 p. 159 and Eighth An. Rep. for 1895, p. 209.

OBSERVATIONS FOR THE PURPOSE OF ASCERTAINING IF A LACK OF LIME IS MORE OR LESS GENERAL IN RHODE ISLAND SOILS.

C. O. FLAGG, H. J. WHEELER AND G. E. ADAMS.

It may be of interest in this connection to mention briefly the steps which have lead to the inauguration of these tests in various parts of the State. In 1890 a number of co-operative experiments were conducted in different sections of Rhode Island for the purpose of ascertaining, so far as might be possible, the needs of the respective soils for potash, phosphoric acid and nitrogen. In combination with these experiments was a trial of different forms of nitrogen, namely: dried blood, ammonium sulfate and sodium nitrate. In the experiment upon the Station farm ammonium sulfate exerted an injurious action, which increased with the quantity applied, the yield upon the plots which received this compound being less than upon those upon either side, which received the same amount of potash and phosphoric acid but no nitrogen at all. The second year the action of ammonium sulfate, in the Hope Valley experiment, was inferior to that of the other forms of nitrogen. The third year a very marked poisonous action was noticed, while an inefficiency of the ammonium sulfate, as compared with other forms of nitrogen, was beginning to be observed in the experiment at Abbott Run, R. I.

In considering the probable cause of this ill effect of ammonium sulfate various possibilities suggested themselves. It seemed probable that the difficulty might be due to the fact that the soil was in some respect not in a condition suited to the ready nitrification of the ammonium sulfate, and that this compound had in its unaltered condition acted as a poison, or that it had entered into combinations or undergone changes in the soil by which poisonous compounds were formed or set free, all of which would probably not have resulted had all of the conditions which are particularly favorable to nitrification existed. It appeared, however, upon careful consideration, that the difficulty was due to a lack of nitrifying organisms in the soil by which the change of ammonia to nitric acid is effected, or else to the fact that the soil was too alkaline or too acid for their growth, and for the consequent change of ammonia to nitric acid.

The soil at Kingston was tested and found to be decidedly acid. It appeared probable therefore that the whole difficulty was due to the extreme acidity of the soil, a view which was still further strengthened by the report of experiments by Müntz[1] indicating the probable universal presence of nitrifying organisms. From nitrification experiments conducted by others it had been shown that nitrification ceases in too acid media, and it seemed probable that lime in the form of wood ashes, air-slacked lime, calcium hydrate, calcium carbonate, or marl, would be the most economical means of correcting the acid condition of the soil. Air-slacked lime was, however, chosen for the reason that it was to be had at limited cost, and it was desirable to employ if possible material such as our own farmers could easily obtain. As a result of the succeeding experiments in 1891, 1892 and 1893, it was proved most conclusively that the ill effect of ammonium sulfate in the soil could not only be entirely prevented by the use of air-slacked lime both at Kingston and at Hope Valley, but that after this treatment the ammonium sulfate became a valuable manure.[2]

Having recognized in two sections of the State a positively ill effect from ammonium sulfate, due presumably to excessive acidity of the soil, and also a much less effect as compared with nitrate of soda in a third section, presumably due to the same cause, the next point which suggested itself was to determine if the upland or naturally well drained soil of the Station farm was sufficiently acid to affect seriously the growth of various agricultural plants. In pursuance of this idea experiments have been conducted for a number of successive years, embracing in all nearly 200 varieties of plants, the results of which are embodied in this and previous reports.[1] In the course of these experiments it has been ascertained that certain of the leguminous plants, such as the serradella and lupine, grow better upon such a soil before than after liming, while clover, alfalfa and others of the same family of plants, are practically a failure until liming has been resorted to. Among the cereals, rye shows no immediate benefit, though benefit from liming is observable a few years subsequent to its application. Oats are immediately benefited to some extent, wheat even more, and barley most of all. The watermelon has been injured, and one season most seriously, by liming, while the muskmelon was almost a failure without it. Among the grasses, Rhode Island bent, red top, meadow soft grass and sheep's fescue are able to flourish on the unlimed soil, though they are apparently somewhat benefited by liming, while timothy and Kentucky blue grass appear to be almost total failures until lime is applied. Similar differences have likewise been observable in relation to other plants. It may be said, however, in connection with the vegetables and those plants usually grown in Rhode Island, that, with but few exceptions they have been, under favorable conditions, benefited immediately by an application of lime. Some of those plants which appear to be slightly injured while a portion of the lime is still in the caustic state, are subsequently benefited by it when it has become neutralized by its contact with the soil.

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[1] Compt. rend. 110 (1890) p. 1370, Abs. E. S. R. Vol. III, pp. 114-116.

[2] For a detailed account of these investigations see Sixth An. Rep. R. I. Agrl. Expt. Sta. 1893, pp. 206-267.

Having recognized the injurious effect of such a soil upon many of the plants which are grown in Rhode Island, the next step which suggested itself was to ascertain how general such conditions were within the State. Soils from various parts of Rhode Island had been tested with blue litmus paper during the experiments described above, most of which were found to be more or less acid, yet the data thus secured did not seem sufficient to justify definite conclusions in relation to this matter, without having conducted special culture experiments. Accordingly a beginning in this direction was made in 1895, when two plots were laid out upon the farm of Mr. F. P. Babcock, of Westerly, R. I. This particular farm was selected for the reason that Mr. Babcock had previously stated to one of us that he had met with some difficulty in the raising of beets, spinach and lettuce, upon certain portions of his farm, even when an abundance of potash, phosphoric acid and nitrogen was applied, in the form of commercial fertilizers, and also in view of the fact that upon testing his soil it was found to be decidedly acid in its action upon blue litmus paper. In this experiment the two plots were manured at the same rate with dissolved boneblack, muriate of potash and nitrate of soda. Nitrogen, in the form just mentioned, was employed, so that the plant could have at immediate disposal a large supply of directly assimilable nitrogen. If the lime facilitated the nitrification of the humous nitrogen, as would be expected, thereby producing a greater quantity of assimilable nitrogen upon the limed plot, then this factor would not come into consideration, or at least not to such an extent as would have been the case were little or no directly assimilable nitrogen applied. By such a course, only, could conclusions be reached as to the physical, manurial and neutralizing effect of the lime. As a result of this experiment, 63 pounds of beets were obtained upon the unlimed, and 155.5 pounds upon the limed plot. Mr. Babcock has this season made a practical application of this experiment in his market gardening operations, in relation to which we will quote from his own letter.

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[1] Sixth An. Rep. R. I. Agrl. Expt. Sta., 1893, pp. 224-252; Seventh An. Rep., 1894, pp. 152-167; Eighth An. Rep., 1895, pp. 205-214.

"In answer to your letter asking for my experience in the use of lime the past summer, I would say that I have raised beets for the past six years with rather poor success; we had to fertilize very highly, and market them as soon as they were large enough, or they would grow stringy and lose their sweetness. After an experiment last year with lime I concluded to use it on my beets this season. I used about twelve barrels to the acre, slacking with water, using just enough to leave it dry and fine like meal. We spread it after plowing, and mixed it with the soil by harrowing. The seed germinated much better where the lime was used, and the beets were at least ten days earlier for market, being of the finest quality. As the season advanced they grew to be immense in size, but retained their good qualities to the end of the season. In conclusion I would say that if the farmers of Rhode Island would give lime a trial on beets of all kinds, also in seeding to timothy and clover, they would be surprised at the results."

In the winter of 1895 and 1896 it was planned to conduct, the following summer, a number of similar experiments, in various localities in the State. Accordingly one or the other of us visited various sections for the purpose of locating such experiments, several of them having been located upon farms of parties who had voluntarily expressed a desire to co-operate with us in this way. The only experiment, so planned and located, upon which no report at all is rendered, was one at Arnold's Mills. Owing to the unfortunate illness of a member of the farmer's family he was prevented from devoting to it the proper attention, so that the experiment was necessarily abandoned. In each case two plots were laid out, each 27 feet square, and separated from each other by a path 6 feet wide, so that the fertilizer or lime might not be dragged from one plot to the other. Each plot contained, therefore, approximately 1/60th of an acre, to which was applied 5 pounds of muriate of potash, 5 pounds of nitrate of soda, and 15 pounds of dissolved boneblack. This quantity, after thorough mixing, was distributed as uniformly as possible over the entire plot. To one of these plots 82 pounds of freshly air-slacked lime were applied, or approximately 2½ tons per acre. Each of these plots was now divided across the center, and 9¾ ounces of barley and 2¾ ounces of red clover seed were sown broadcast upon one-half of each, as early in the season as possible, while upon the other half ¾ of an ounce of table beet seed was sown in drills. A small sample of soil from each of the locations was examined with litmus paper in the manner described in the Eighth Annual Report of this Station for 1895, page 237. Other examinations were also made for the purpose of gaining some idea of the amount of humus directly soluble in ammonia, for it is well known, that in soils which contain an excess of lime, in the form of calcium carbonate, the lime unites with the humus, forming a compound which is insoluble in ammonia until after the soil has been extracted with hydrochloric acid. It seemed therefore probable, if these soils contained any considerable amount of humus directly soluble in ammonia, that a deficiency of lime must exist, and that, consequently, in an experiment of this kind, some benefit would be shown from its use. It will be obvious that if acid soils exist to a considerable extent within the State, it would be of the utmost importance to find a simple means by which the farmer himself can ascertain this particular deficiency. It would also be desirable to elaborate a method by which the Experiment Station can determine for the farmers the relative acidity of different soils, so as to advise more wisely in regard to the quantity of lime to be used in particular cases. The work which is being done in this line is not concluded, and will not be discussed here. We shall confine ourselves in this place to a mere statement of the results of the litmus paper tests, and of the other examinations referred to above.

Location.	Test with Blue Litmus Paper.	Approximate Test of Direct Solubility of the Humus by Ammonia.
Warren.	Slightly alkaline.	Little soluble.
Harrisville.	Slightly acid or neutral.	Very little soluble.
Hope Valley.	Acid.	Considerable soluble.
Niantic.	Quite acid.	Considerable soluble.
Summit.	Quite acid.	Considerable soluble.
Slocumville.	Intensely acid.	Very large amount soluble.
South Portsmouth.	Quite acid.	Considerable soluble.
Conanicut Island.	Somewhat acid.	Considerable soluble.
Hamilton.	Very acid.	Much soluble.
Foster Center.	Decidedly acid.	Very much soluble.
Kingston (hill).	Intensely acid.	Very large amount soluble.

In the case of the Warren experiment the barley was so infested with weeds that it was out of the question to attempt to assort and weigh it, so that these results were omitted. At Hamilton the growth of weeds was so great that the barley was practically smothered at the outstart so that the weeds and barley were cut together at an early date, and no attempt was made to record the weight of the barley. At Conanicut Island farm animals, presumably sheep, had evidently gained access to the plots at some time, and slightly injured the barley upon the edges of the plots, and appearances indicated that it had been subsequently injured by army worms, which were present in the locality, so that no attempt was made to weigh this crop. At Kingston, Slocumville and Foster Center the weeds were removed so far as possible from the barley, and the weights of the latter recorded. One of us was present in most instances when the fertilizer was applied and the plots planted, and likewise in every instance, with but one exception, at the harvesting of the beets and of the barley. Upon arriving at Foster Center, the barley, owing to a local shower, was too wet to be cut and weighed, on which account Mr. Spears kindly harvested, assorted and weighed it, and subsequently reported the results. The beets at Warren were harvested and photographed by us, but were left, on account of an approaching storm, to be weighed by Mr. Arnold, who kindly forwarded to us his report in relation to them. The result of these experiments may be found in the following table: (*See illustrations. Figures 1 to 13.*)

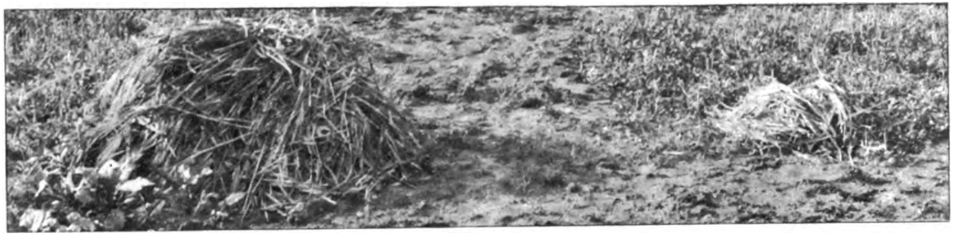

FIG. 1.—BARLEY. (Slocumville, R. I.)

Limed. *Unlimed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

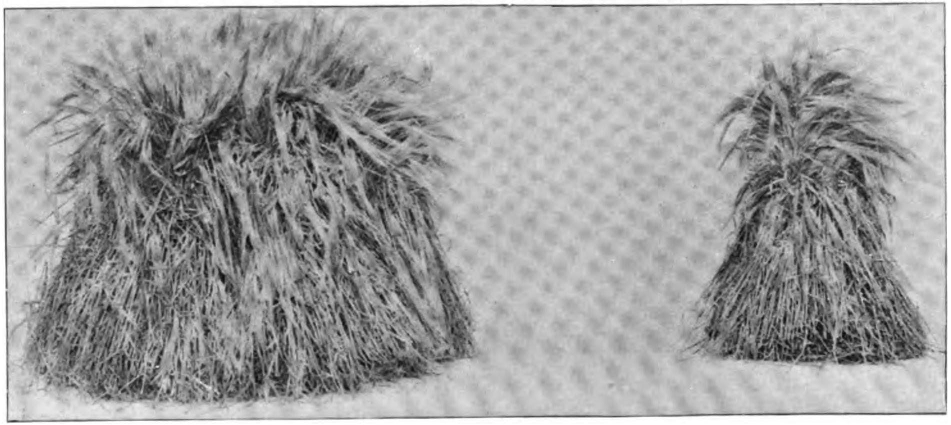

FIG. 2.—BARLEY. (Kingston Hill, R. I.)

Limed. *Unlimed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

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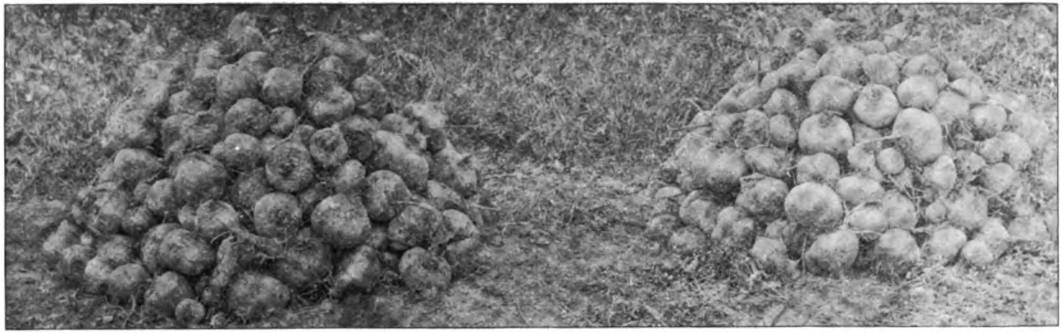

Fig. 3.—Table Beets. (Warren, R. I.)

Limed. *Unlimed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

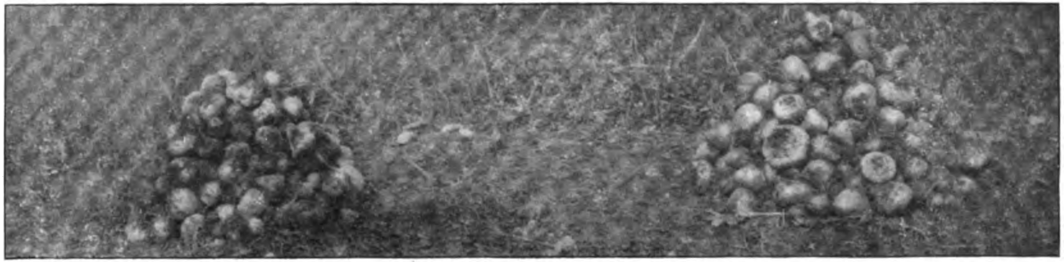

Fig. 4.—Table Beets. (Harrisville, R. I.)

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

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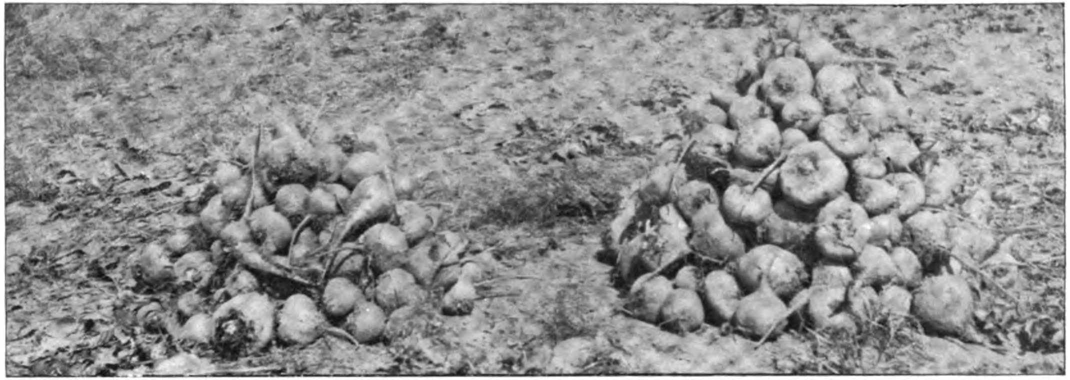

Fig. 5.—Table Beets. (Conanicut Island, R. I.)

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

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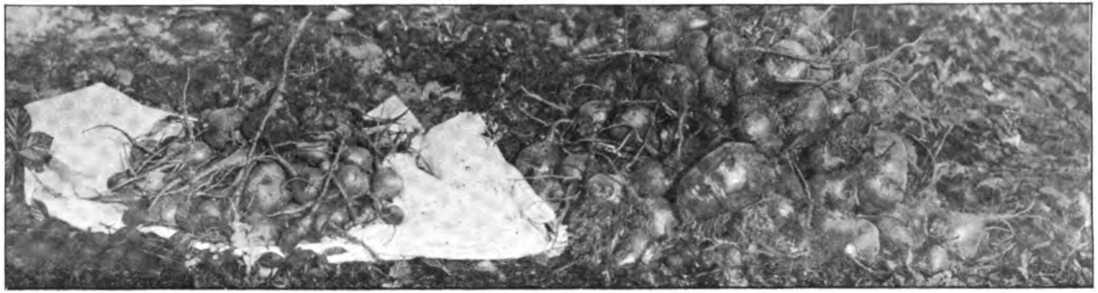

Fig. 6.—Table Beets. (Niantic, R. I.)

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

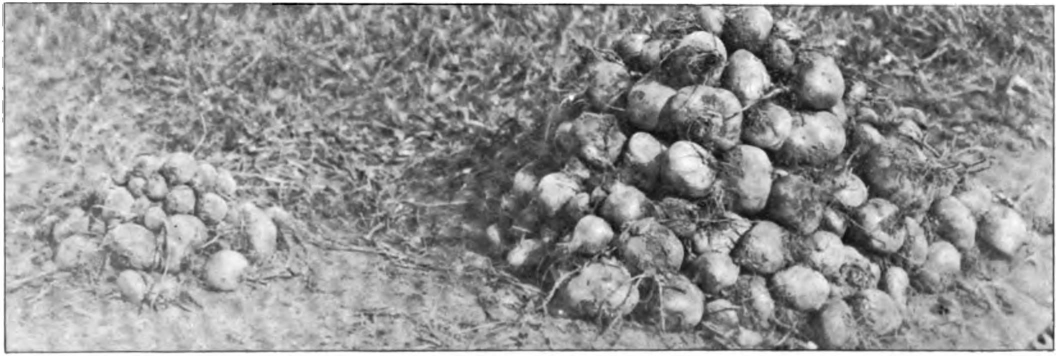

Fig. 7.—Table Beets. (Hamilton, R. I.)

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

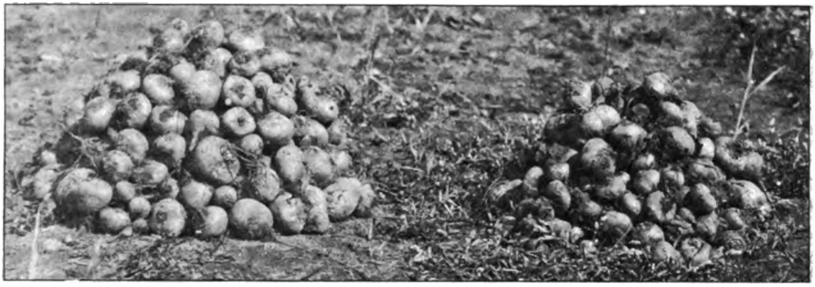

FIG. 8.—TABLE BEETS. (Hope Valley, R. I.)

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

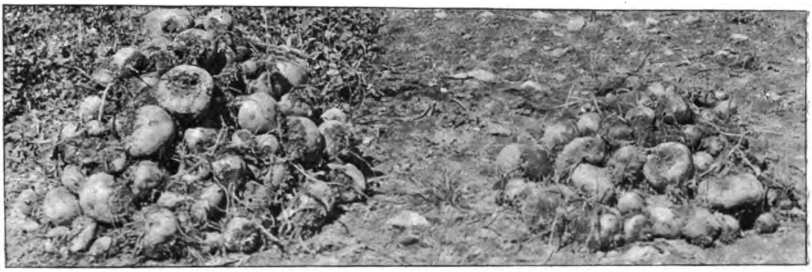

FIG. 9.—TABLE BEETS. (Summit, R. I.)

Limed. *Unlimed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

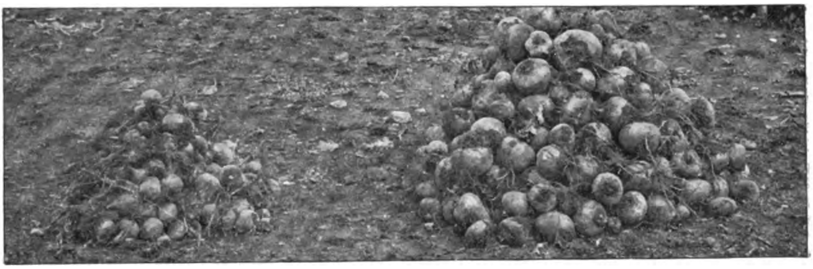

FIG. 10.—TABLE BEETS. (Foster Centre, R. I.)

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

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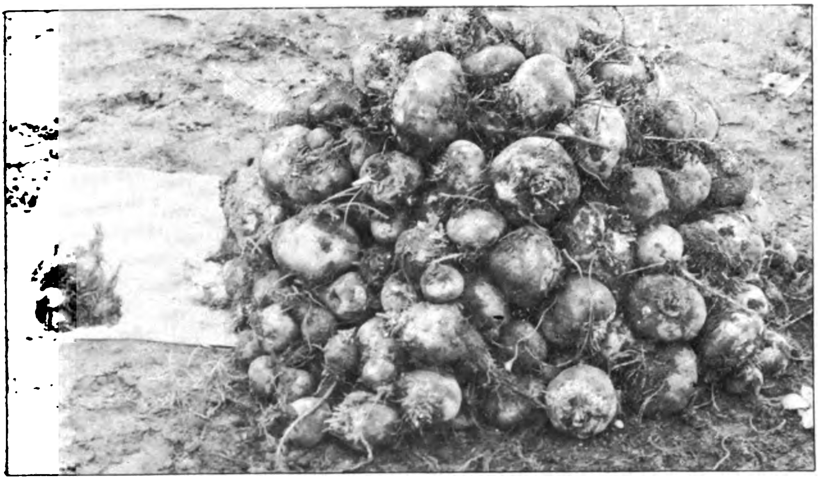

FIG. 11.—TABLE BEETS. (Slocumville, R. I.)

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

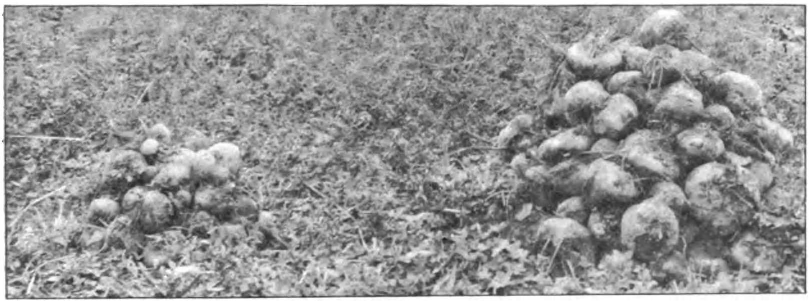

FIG. 12.—TABLE BEETS. (South Portsmouth, R. I.)

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

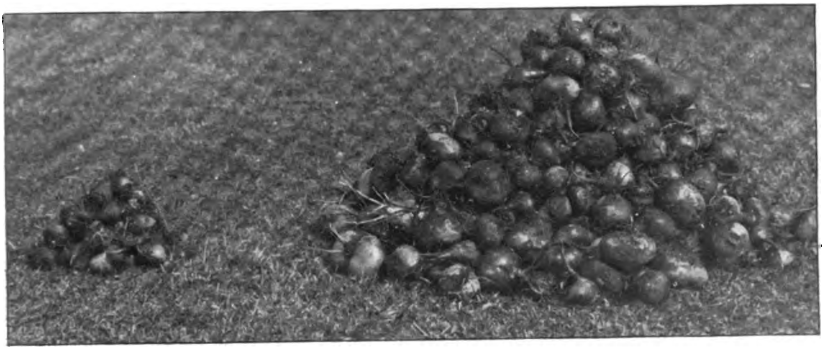

FIG. 13.—TABLE BEETS. (Kingston Hill, R. I.)

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

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Table showing the Effect of Air-Slacked Lime upon the Growth of Barley and Beets in Various Sections of Rhode Island.

LOCATION OF EXPERIMENT, AND NAME OF CO-OPERATING PERSON.	TABLE BEETS. (Tops not weighed.)		BARLEY. (Cut while in the milk.)	
	Limed. (lbs.)	Unlimed. (lbs.)	Limed. (lbs.)	Unlimed. (lbs.)
WARREN.				
G. W. Arnold	329.0	272.0	*	*
HARRISVILLE.				
W. E. Fitz.	207.3	151.5	75.3	91.7
HOPE VALLEY.				
R. C. Nichols.	74.4	140.6	49.3	62.3
NIANTIC.				
E. W. Vars.	43.4	9.9	12.6	23.0
SUMMIT.				
B. H. Nixon.	92.9	47.4	42.6	35.4
SLOCUMVILLE.				
Alfred Eldred	101.8	1.0	39.1	3.7
SOUTH PORTSMOUTH.				
N. H. Peckham.	153 0	26.0	129.0	133.0
CONANICUT ISLAND.				
E. N. Tefft	152.7	75.8	†	†
HAMILTON.				
G. W. Larned	138.1	14.5	*	*
FOSTER CENTER.				
J. B. Spears	143.4	36.6	58.3	54.0
KINGSTON (HILL).				
Agricultural Expt. Station.	161.4	6.6	58.0	13.0

* Owing to the weedy condition of these plots it was found impracticable to secure the weights of the barley.

† The crop was slightly injured by farm animals on one occasion, and possibly by army worms, and was in consequence not weighed.

From an inspection of this table it will be seen, in the case of the barley, that at Harrisville, Hope Valley and Niantic the yields were less upon the limed than upon the unlimed plots. At South Portsmouth, however, there was a gain of 3 per cent. upon the unlimed plot; at Foster Center a gain of 8 per cent.; at Summit a gain of 20 per cent.; while at Kingston the crop was increased more than four times, and at Slocumville between 10 and 11 times. In previous experiments with barley, at Kingston, it has been invariably benefited by liming, even when the lime was applied immediately before the barley was sown, yet our soil is not extremely light, and it is intensely acid, two factors which probably serve to explain why an injurious effect is not produced under such circumstances. In experiments with rye, even upon our own soil, injury to the crop seems to have been caused when lime has been applied immediately before the rye was sown, though upon the same soil a benefit from liming, in connection with the rye crop, has been visible in cases where the lime was applied some two or more years before. The same thing has been noted likewise in connection with carrots, and, in fact, it appears probable that certain plants are benefited by lime only when it is applied long enough beforehand so that its causticity is first entirely overcome. Other plants, such as the beet, spinach and lettuce seem to be less liable to injury in this way, and in all of the experiments thus far conducted on our own soil they have shown decided benefit from an application of lime immediately before the seeds are sown. That the character of the soil would determine, in a great measure, the effect of applications of lime directly before the seeds are planted appears to be unquestionable, for in articles relating to lime the recommendation seems to be general to apply but small quantities of it in a single application upon soils which are very light or sandy, while larger applications may be made upon soils which are more compact and which contain large quantities of organic matter in an acid state. It is to be presumed, therefore, that the injury to the barley crop in the three cases mentioned above, as well as that to the beet crop at Hope Valley, was attributable to the large application of lime (most of which was undoubtedly not combined with carbonic acid[1]) immediately before the seeds were sown. It would therefore be of particular interest to grow barley upon these plots again, after opportunity has been afforded for the lime to be entirely changed into calcium carbonate, in order to see whether it would not then show a beneficial after effect from the application. The only two cases, upon soils showing any considerable amount of acidity, where any injury from the use of lime in connection with barley was noticeable were those of the Hope Valley and Niantic soils, both of which were extremely light. That the beets in the case of the Niantic experiment did better upon the limed plot than in the experiment at Hope Valley may readily be attributable to more moisture, due to the closer proximity of the water in the subsoil of that field. In connection with the result with beets it will be seen, from the foregoing table, that the least gain from the use of lime was in the case of the Warren soil, where it was only 21 per cent., and it should be noted that this was the only soil which appeared to be neutral, or slightly alkaline. In the case of the Harrisville experiment the soil seemed to be only slightly acid and, in fact, the gain from liming, which amounted to nearly 37 per cent., stands closely in accord with the results obtained by the litmus paper test, or, in other words, with the probable degree of acidity of the soil. It will be seen that the yield of beets at Foster Center was increased nearly four times, at Niantic more than four times; at Hamilton it was increased nearly nine times, at South Portsmouth nearly six times, on the island of Conanicut and at Summit the crop was almost doubled, while at Kingston and at Slocumville the increase from liming was enormous in comparison with the other experiments. While we cannot give any exact data in this connection as to the relative acidity of the soils, it may be stated that, judging from the action upon blue litmus paper, the two soils which were most acid, were those at Kingston and at Slocumville, which showed, in fact, the greatest benefit from liming, both in connection with beets and with barley. On the other hand, the two which showed the least benefit from liming, in connection with the beets, were those which were neutral or nearly neutral, so far as concerned their action upon blue litmus paper. These results appear, therefore, to indicate that it may be possible, if a satisfactory method of determining the relative acidity of soils can be developed, to predict, with a great degree of certainty, how great the benefit from lime upon a particular soil would probably be, and, employing such a test in connection with a physical examination of the soil, it seems very probable, likewise, that one may be able to prescribe, with a considerable degree of accuracy, as to the quantities of lime which it would be safe to apply in any particular case. In fact this experiment had two objects in view, namely: to ascertain how general the need of lime might be in the State, and to determine whether its application would be useful in many sections in connection with the growth of barley, beets, clover and timothy, the latter two of which are among the most important agricultural crops of the State. It was also hoped to thus place on record the relative gains produced by liming the various soils, in order that the data thus obtained could be compared with the results of later chemical investigations in relation to the acidity of the soils, with the hope thereby of establishing some reliable chemical method by which one could prescribe, in the future, with considerable accuracy, in relation to the needs of particular soils. The only way to establish definitely whether such a test is reliable or not seemed to be that outlined; that is, to ascertain, by actual experiment, whether the same story would be told by the chemical test as by the plants themselves. If the reliability of a given chemical test could thereby be established, then the necessity for the multiplication of field tests in all parts of the State, for the purpose of determining a lack of lime, would be eliminated, and it would become possible, by an examination of a sample of soil taken from any field, to decide as to its probable requirements as regards lime. Investigations in this line are now in progress, the results of which will be published at a later date. It may be necessary to continue these observations for several years before the reliability of any given chemical test can be definitely determined.

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[1] Most of the lime used in the experiments at this Station heretofore had been exposed to the air for a longer time than that employed in these experiments. In fact we were informed that the delay which occurred in the shipment of this lime was due to the fact that the parties from whom it was ordered waited for it to air-slack, so that much of it must have been uncombined with carbonic acid, in which form it would have just the effect noticed, particularly on a light soil in time of drouth. It should be noted likewise that the Hope Valley soil was, at the time of planting, extremely dry, and in fact it was in such condition that the beet seed, particularly upon the limed plot, failed in many cases to germinate or the plants to make any considerable growth.

SUMMARY.

The results with barley have shown in a number of instances a benefit from lime, even when it was applied in considerable quantity directly before the sowing of the grain. In four instances, where the barley was not benefited, it seems probable that such would have been the case had the lime been applied a year before, or had the quantity been much less. In the experiment with beets they were benefited decidedly by liming, in every case but one, the least gain obtained having been 21 per cent., while in other cases the crop was increased six, nine, twenty-six, and in one case even one hundred times. The barley is being followed by clover, and the beets by timothy, the results with which it is hoped may be published another season, thus placing on record data secured with two of our most important farm crops.

FURTHER OBSERVATIONS FOR THE PURPOSE OF DETERMINING WHETHER THE BENEFICIAL ACTION OF LIME UPON THE SOIL OF THE EXPERIMENT STATION FARM IS DUE TO ANY EXTENT TO ITS NEUTRALIZING ACTION.

H. J. WHEELER, G. M. TUCKER AND B. L. HARTWELL.

In connection with the three years' observations already made upon the growth of various plants, upon the farm of the Experiment Station, upon limed and unlimed soil, it has been ascertained that some kinds of plants perish in large numbers upon the unlimed soil, while others, notably the lupine, serradella, and watermelon, succeed better before than after liming. Experiments at Hope Valley and Westerly confirmed the belief that other Rhode Island soils might be suffering, in some degree, from similar causes. The experiments with beets and barley which have been conducted the past season,[1] for the purpose of ascertaining if deficiencies of calcium carbonate (carbonate of lime) are more or less general in the State, have established conclusively that such is the case. Having approached this side of the question it seemed desirable also to ascertain, first in connection with our own soil, and perhaps later with others, whether this beneficial action of lime was attributable to its manurial, physical, or neutralizing action; for upon this would depend in a measure the tests which should be applied to soils for the purpose of determining one of their important requirements. If a soil were suffering from a deficiency of lime, solely from a manurial standpoint, it would be expected that a determination of the amount of lime which could be dissolved from it, under definite conditions, by hydrochloric acid, would give indications as to its need of liming, and that an application of gypsum (land plaster) would perhaps prove as effective as one of lime in the form of marl, wood ashes, air or water-slacked lime, or calcium carbonate.

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[1] See this Report. pp. 282-293.

If our soils were suffering from a deficiency of certain substances solely for need of their flocculating action upon the fine particles of clay which they contain, then from the experiments by Robert Sachsse and Arthur Becker,[1] in which it was shown that monocalcium phosphate has a greater flocculating power than either lime or gypsum, it would not appear that a chemical test, but rather a physical examination, of the soils was demanded for ascertaining their needs. Deficiencies in this respect having been demonstrated, it would then seem more reasonable to apply superphosphates than lime, particularly upon our Rhode Island soils, many of which are notably deficient in phosphoric acid. In the case of our Experiment Station soil we have abundant evidence that our trouble is not to be sought solely in a deficiency of flocculating ingredients, for otherwise a most beneficial action should accompany the application of superphosphates, in connection with plenty of assimilible potash and nitrogen, in all instances, and with an abundant supply, but little, if any, beneficial action from lime would be expected. Such has not, however, proved to be the case; certain plants which are most benefited by lime having proved almost total failures when grown under such conditions.[2] If the beneficial action of the lime upon the soils of the State is attributable in any considerable degree to its tendency to reduce their sourness or acidity, then the importance of the recognition of this fact, and the subsequent investigation of such culture and chemical tests as would be best suited for the recognition of this condition, as well as the degree of acidity existing, must be of paramount importance. It is our intention in this connection to touch only upon the first question involved, namely: whether the beneficial action of lime upon our soil is due to any extent to its function as a neutralizer of acidity. It is perhaps unnecessary to cite authorities to show that, though the acid humous bodies are themselves practically insoluble in water, yet they are capable of combining chemically with the lime of calcium carbonate, perhaps chiefly through the intervention of soluble bicarbonate, which is produced within the soil. That such is the case is indicated by the fact generally accepted, that where there is an excess of calcium carbonate in a soil, none or but little of its humus exists uncombined with lime or magnesia, and is therefore present in combinations not directly soluble in ammonia. Such was found by us to be true of a sample of "Adobe" soil, kindly sent by Prof. Arthur Goss, from the valley of the Rio Grande, in New Mexico, and it is also true of the "Tschernozeme" or black soil of Russia,[1] so well known for its enduring fertility. In another place[2] we have called attention to certain data which indicated that the benefit from liming noticeable upon the upland soil of the Experiment Station farm, was attributable in a marked degree to its neutralizing function, whereby the prevailing acidity was reduced. Still further data which have been obtained in the same connection are embodied below:

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[1] Die landw. Vers. Sta. 43, 1894, p. 22, cited in E. S. R., Vol. 5, p. 696.

[2] See Sixth An. Rpt. R. I. Agrl. Expt. Station for 1893, pp. 224–250; also Seventh An. Rpt. for 1894, pp. 152–167, and Eighth An. Rpt. for 1895, pp. 203–214.

DATA BEARING UPON THE QUESTION WHETHER THE BENEFIT FROM LIMING OUR EXPERIMENT STATION SOIL IS ATTRIBUTABLE IN ANY DEGREE TO THE NEUTRALIZING ACTION OF THE LIME.

Experiment A. This experiment was conducted in the same soil and pots which were used for experiments with spinach in 1894, and with lettuce in 1895.[3] A generous application of dissolved boneblack, muriate of potash and nitrate of soda, at the same rate per pot, was made annually in each of the first two years of the experiment. In 1896 the respective amounts applied per pot were as follows: twenty-five, ten and twenty grams. Pot 59 received annually, from 1894 to 1896, inclusive, 8.3 grams of sodium carbonate (one-half ration), and pot 60 double the amount, or 16.6 grams (full ration), which was equivalent to an annual application of 900 pounds per acre. The following are the results obtained with lettuce in 1895.

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[1] P. Kostytsch, Annales Agron. 17, 1891, p. 88; also Forschungen auf dem Gebiete d. Agrikultur-Physik 15. 1892, p. 47.

[2] Eighth An. Rpt. R. I. Agrl. Expt. Station for 1895, pp. 254–275.

[3] Ibid p. 267.

Pot 57, without sodium carbonate	0.0 grams.
" 58, " " "	0.0 "
" 59, one-half ration of sodium carbonate	19.0 "
" 60, full " " " "	115.9 "

In 1896 barley was grown, a like number of grains having been planted in each pot. The conditions were maintained, as in previous years, as uniform as possible. The barley was cut while in the milk, and allowed to dry under uniform conditions for several weeks in the Station laboratory. The following are the weights thus obtained:

Pot 57, without sodium carbonate	136.8 grams.
" 58, " " "	115.9 "
" 59, one-half ration of sodium carbonate	132.3 "
" 6,0 full ration of sodium carbonate	135.6 "

The results from plots 57 and 58 are not as concordant as could be desired, but in view of the fact that the yield from pot 57 was greater than from either pot 59 or 60, they indicate no probable benefit from the use of sodium carbonate. The results stand, therefore, in strong contrast to those secured with lettuce the preceding year. The cause for this may not be at once apparent, and would possibly not admit of ready explanation, were it not for data secured in other experiments[1] with these crops. In 1893 lettuce and barley were both grown upon plots Nos. 23, 25, 27 and 29, and comparing the products from plots 27 and 29, both of which had received their nitrogen in the form of nitrate of soda, it appears that the yield of lettuce was 77.9 times as great upon the limed plot (29) as upon the other, while in the case of barley, the yield on the limed plot was but 1.8 times as great. In 1894 both of these plants were again grown upon the same plots, the yield of lettuce upon the limed plot being ten times, and that of barley 2.06 times as great as upon the unlimed one. It will be seen, therefore, that lettuce was benefited much more than barley, by lime, or, what (based upon our entire experiments along these lines for three consecutive years) seems probable, lettuce was more susceptible than barley to injury by soil acidity. In further support of this view it should be stated that the soil of plots 23, 25, 27 and 29 had been shown, by previous culture experiments without manure, to be very uniform, and upon one of these plots (23), sulfate of ammonia exerted a most serious ill effect the first year it was applied, while, in the case of the soil employed in the pot experiments mentioned above, an ill effect from applications of sulfate of ammonia was not noticeable until the third successive year. It is therefore highly probable that the cause for an apparent benefit, in connection with the use of sodium carbonate upon lettuce and not upon barley, was not attributable wholly, as one might under certain circumstances have concluded, to a direct fertilizing action of the soda upon lettuce, and not upon barley; but rather, chiefly, if not wholly, to the different degree of acidity of the two soils. It might perhaps be objected that barley should have shown decided benefit from the applications of sodium carbonate in view of the injury it suffered in the experiments above cited upon plot 27, yet our observations already made, in connection with nearly one hundred and fifty varieties of plants, together with those recorded elsewhere in this Report,[1] lead to the conclusion that upon a soil which is so well suited to barley that an alkaline treatment will not increase, but rather diminish the crop, such a treatment of the soil would augment the yield of lettuce, beets, or spinach, which seem more sensitive than barley to injury upon acid soils. It will be obvious, therefore, that though the results with barley in 1896 do not furnish direct evidence that the difficulty with our soil is to be sought chiefly in its acidity, yet taken in connection with the results with lettuce, and the other experiments cited above, they do tend to corroborate, indirectly, such an idea.

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[1] Wheeler, Towar and Tucker, Seventh An. Rpt. R. I. Agrl. Expt. Station, 1894, pp. 158, 159.

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[1] See pages 282 to 293.

Experiment B. This experiment was conducted in pots and soil like those employed in experiment A. Mangel wurzels were grown in these pots in 1894 and 1895, the results with which have been published elsewhere.[2] Applications of potash, phosphoric acid and nitrogen, were made annually for the three years at a like rate per pot, though in the case of potash it was applied to certain pots as muriate, and to others as carbonate. Barley was employed in 1896 with the expectation that a sufficient degree of acidity existed in those pots which had not had an alkaline treatment, to materially influence the yield. As will be seen from the subjoined table such did not prove to be the case. Another reason for making a trial of barley in lieu of beets, spinach, or lettuce, was that more plants could be grown in each pot, whereby differences due to the individuality of plants would less seriously affect the results. Applications of air-slacked lime, sodium carbonate and caustic magnesia, were made to certain of the pots in both 1894 and 1895, but in 1896 these were omitted, in order that the relative after-effect from their use might perhaps be ascertained. Air-slacked lime was applied in 1894 at the rate of 91.98 grams per pot, or equivalent to 2½ tons per acre, and in 1895 at the rate of 18.4 grams per pot, or so that the total application for the two years would amount to three tons per acre. The applications of sodium carbonate and caustic magnesia were the same in 1894 as in 1895. The results obtained, as well as such other data as serve to explain the experiment, are embodied in the following table:

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[2] Eighth An. Rpt. R. I. Ag'l Expt. Station for 1895, pp. 260-266.

Table showing the comparative effect, upon the yield of barley, of two previous applications (1894 and 1895) of air-slacked lime, carbonate of soda and caustic magnesia. (See illustration, Fig. 1.)

No. of Pot.	Material Applied. (Each pot received 20 grams of nitrate of soda, and 25 grams of dissolved boneblack.)	Barley.[1] (Cut while in the milk.) Grams.
	Carbonate of Potash Group. (7.7 grams of carbonate of potash per pot.)	
85....	....	132.3
86....	....	125.6
	Muriate of Potash Group. (10 grams of muriate of potash per pot.)	
87....	½ ration of caustic magnesia in 1894 and 1895.	123.3
88....	Full ration of caustic magnesia in 1894 and 1895.	131.2
89....	½ ration of sodium carbonate per pot in 1894 and 1895.	117.7
90....	Full ration of sodium carbonate per pot in 1894 and 1895	128.9
91....	No special addition	125.7
92....	No special addition	125.4
93....	Air-slacked lime in 1894 and 1895	123.7
94....	Air-slacked lime in 1894 and 1895	121.2

The above results are in striking contrast to those secured with mangel wurzels the two preceding years, for in both of those years the yields from the pots which received their potash in the form of carbonate (85 and 86), as well as from those where muriate of potash was employed without alkaline substances (91 and 92), were greatly inferior to those from the other pots. It is possible that those pots which had produced inferior yields during the two preceding years enjoyed a certain advantage over the others in 1896, owing to an accumulation of an excess of plant food left behind by the previous crops. A large application of potash,

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[1] Air-dried for several weeks in the chemical laboratory.

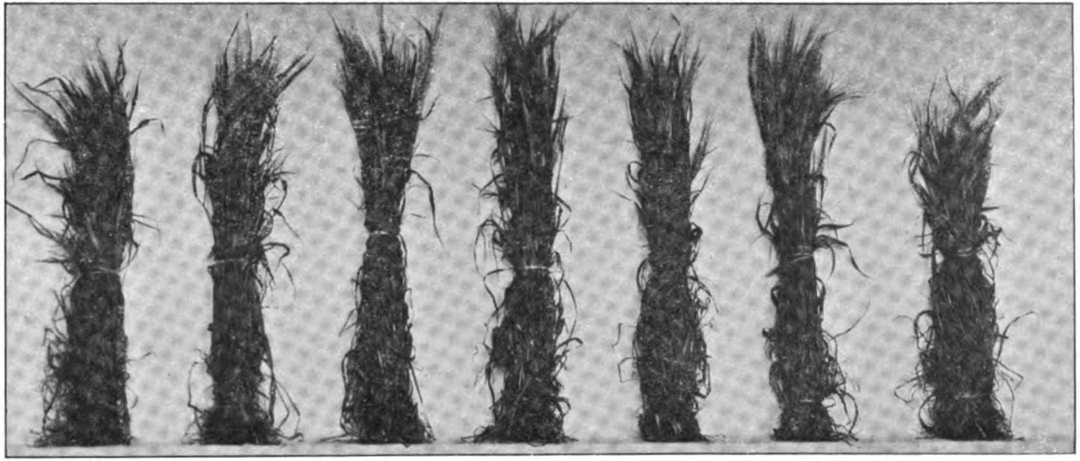

FIG. 1.—BARLEY.

1. Received carbonate of potash.
2. " muriate of potash and a one-half ration of caustic magnesia.
3. " " " " full " " "
4. " " " " one-half " carbonate of soda.
5. " " " " full " " "
6. " " "
7. " " " and air-slacked lime in 1894 and 1895.

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phosphoric acid and nitrogen was made, however, in 1896, with the hope of supplying all of the plants abundantly, in order that any accumulated residues of preceding years might not affect the results. It will be seen that probably no influence of this kind was exerted.

These results, like those with lettuce given under experiment A., do not, of themselves, furnish any evidence that acidity of the soil is a factor to be considered. However, in this case the same arguments hold as in experiment A., for, upon comparing the relative yields of mangel wurzels and barley obtained in other experiments,[1] it appears that when grown as here, in connection with dissolved boneblack, muriate of potash, and a generous supply of nitrate of soda, the yield of barley in 1894 was only 1.8 times as great upon the limed, as upon the unlimed plot, while that of mangel wurzels was 7.59 times as great where lime was applied. The relative increase of these two crops in 1895 was represented. by 2.06, and 5.77 respectively, which, taken in connection with the very conclusive results secured in the co-operative experiments, conducted about the State in 1896, indicate that beets, as well as lettuce, are benefited by lime much more than barley. The question which naturally arises is whether this benefit from lime was due chiefly to its physical, fertilizing, or neutralizing function. The results with beets in 1894 and 1895[2] showed a most marked and nearly equal benefit from applications of large quantities of caustic magnesia, sodium carbonate, and air-slacked lime, a fact which, to admit of satisfactory explanation upon the idea of physical benefit solely, would necessitate attributing practically a like action to each; and, furthermore, if the physical character of the soil had been so changed as to have such a marked influence upon the grown of beets, it would be highly surprising that the influence should so suddenly have ceased, or that it should not have proved to be an important *favorable* or *unfavorable* factor in the subsequent growth of barley. That each of the three ingredients should have exerted an almost identical action, as direct manures for the beet, is too improbable to require consideration, and had such been the case, it would seem surprising that none of them exhibited any marked specific effect in connection with barley. It appears probable, therefore, *viewing this experiment in connection with others which have preceded it*, that the theory of soil acidity furnishes the most satisfactory explanation for the facts observed.

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[1] Seventh An. Rpt. R. I. Agrl. Expt. Station for 1894, pp. 158-159.

[2] Eighth An. Rpt. Agrl. Expt. Station for 1895, p. 264.

Experiment C. This experiment was conducted with pots and soil exactly like those employed in experiments A. and B. The most important difference between this and the preceding experiments is that sulfate of ammonia was employed in this case as a form of nitrogen, on account of the fact that the residual product would be an acid (sulfuric acid) instead of a base, as is the case with nitrate of soda. If, therefore, a greater benefit were found to result from the use of alkaline compounds in connection with it than was observable where nitrate of soda was used, it would point to a probable deficiency of basic soil ingredients, and to soil acidity, which is the customary accompaniment of such deficiencies. This experiment was begun in 1894, but the results obtained the first two seasons were withheld from publication until more positive data were obtainable. The results for the three years will be given in this connection. It should perhaps be stated that the pots in which all of these experiments were conducted were of galvanized iron, 18 inches in diameter, and 26 inches deep, with a bottom sloping towards the center, at which an opening was left. A few small stones were placed in the bottom of each can, after which it was partially filled with subsoil, and finally received 100 pounds of surface soil from plot 00, of the so-called co-operative acre upon the Experiment Station farm. The pots were sunk in the ground to within about two inches of their tops, the same as were those in experiments A. and B. Three maize kernels were planted in each pot, and after the plants were about three inches high the most uniform two were allowed, in each case, to remain.

Table showing the yields obtained with Indian corn (maize) when grown by the aid of sulfate of ammonia, in connection with alkaline materials of various kinds. (Year of 1894.)

Pot No.	MATERIALS APPLIED. (Each pot received 13.529 grams of sulfate of ammonia and 22.07 grams of dissolved boneblack.)	Weight (in grams) after air-drying in the chemical laboratory for several weeks. Total plants.	Grain.
	I.—CAUSTIC MAGNESIA GROUP.		
	(7.86 grams of muriate of potash per pot.)		
32	2.54 grams of caustic magnesia*	291.5	114.7
37	5.08 grams of caustic magnesia	270.8	106 5
42	7.62 grams of caustic magnesia	290.4	99.5
	II.—SODIUM CARBONATE GROUP.		
	(7.86 grams of muriate of potash per pot.)		
33	5.53 grams of sodium carbonate*	254.1	90.0
38	11.06 grams of sodium carbonate	278.0	52.5
43	16.59 grams of sodium carbonate	270.9	92.1
	III.—WOOD ASH GROUP.		
48	Wood ashes, potash equivalent to that in Groups I and II	287.2	105.5
53	Wood ashes, potash equivalent to that in Groups I and II	297.0	92.6
	IV.—POTASSIUM CARBONATE GROUP.		
54	Potassium carbonate, potash equivalent to that in Groups I, II and III	259.8	97.5
55	Potassium carbonate, potash equivalent to that in Groups I, II and III	280.2	101.7
56	Potassium carbonate, potash equivalent to that in Groups I, II and III	272.7	112.5
	V.—WITHOUT SPECIAL APPLICATIONS.		
	(7.86 grams of muriate of potash per pot)		
47	Without special applications	271.8	91.8
52	Without special applications	295.0	121.0

* 2.54 grams of the caustic magnesia were capable of neutralizing the same amount of acid as 5.53 grams of the sodium carbonate. This was determined by actual tests in the laboratory

Table showing the yields obtained with Indian corn (maize) when grown by the aid of sulfate of ammonia, in connection with alkaline materials of various kinds. (Year of 1895.)

POT No.	MATERIALS APPLIED. (Each pot received 13.47 grams of sulfate of ammonia and 25.0 grams of dissolved boneblack.)	Weight (in grams) after air-drying in the chemical laboratory for several weeks. Entire plants.*
	I.—CAUSTIC MAGNESIA GROUP.	
	(10 grams of muriate of potash per pot.)	
32	2.54 grams of caustic magnesia.	185.8
37	5.08 grams of caustic magnesia.	195.7
42	7.62 grams of caustic magnesia	239.9
	II.—SODIUM CARBONATE GROUP.	
	(10 grams of muriate of potash per pot.)	
33	5.53 grams of sodium carbonate	206.3
38	11.06 grams of sodium carbonate	148.2†
43	16.59 grams of sodium carbonate	237.6
	III.—WOOD ASH GROUP.	
48	Wood ashes, potash equivalent to that in Groups I and II	247.2
53	Wood ashes, potash equivalent to that in Groups I and II	222.0
	IV.—POTASSIUM CARBONATE GROUP.	
54	Potassium carbonate, potash equivalent to that in Groups I, II and III	195.6
55	Potassium carbonate, potash equivalent to that in Groups I, II and III	169.9
56	Potassium carbonate, potash equivalent to that in Groups I, II and III	179.5
	V.—WITHOUT SPECIAL APPLICATIONS.	
	(10 grams of muriate of potash per pot.)	
47	Without special applications	179.5
52	Without special applications	199.5

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* Cut just as the grain was about to form.

† One of the stalks appeared to be inferior to all the others, and set no ears, which accounts for the small yield.

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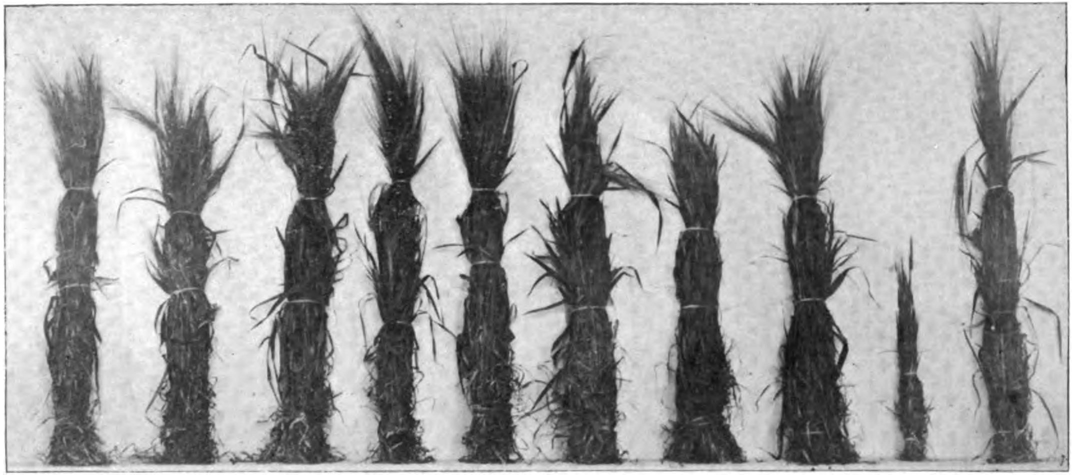

FIG. 2.—BARLEY.

1. Received 2.54 grams of caustic magnesia and also muriate of potash.
2. " 5.08 " " " " " " "
3. " 7.62 " " " " " " "
4. " 5.53 " sodium carbonate " " " "
5. " 11.06 " " " " " " "
6. " 16.59 " " " " " " "
7. " wood ashes.
8. " potassium carbonate.
9. " muriate of potash (Pot 47).
10. " " " " (Pot 52).

Table showing the yields obtained with barley when grown by the aid of sulfate of ammonia, in connection with alkaline materials of various kinds. (*See illustration, Fig. 2.*) (*Year of 1896.*)

POT No.	MATERIALS APPLIED. (Each pot received 18.47 grams of sulfate of ammonia and 25.0 grams of dissolved boneblack.)	Weight (in grams) after air-drying in the chemical laboratory for several weeks. Harvested when "in the milk."
	I.—CAUSTIC MAGNESIA GROUP. (10 grams of muriate of potash per pot.)	
32.....	2.54 grams of caustic magnesia..................	101.4
37......	5.08 grams of caustic magnesia.......	112.5
42.....	7.62 grams of caustic magnesia..................	128.7
	II.—SODIUM CARBONATE GROUP. (10 grams of muriate of potash per pot.)	
33	5.53 grams of sodium carbonate..	80.6
38......	11.06 grams of sodium carbonate................	111 2
43......	16.59 grams of sodium carbonate.....	121 4
	III.—WOOD ASH GROUP.	
48	Wood ashes, potash equivalent to that in Groups I and II..........................	125.4
53	Wood ashes, potash equivalent to that in Groups I and II..	131.0
	IV.—POTASSIUM CARBONATE GROUP.	
54......	Potassium carbonate, potash equivalent to that in Groups I, II and III.....................................	104.3
55......	Potassium carbonate, potash equivalent to that in Groups I, II and III.....................................	95.4
56	Potassium carbonate, potash equivalent to that in Groups I, II and III.....................................	109.7
	V.—WITHOUT SPECIAL APPLICATIONS. (10 grams of muriate of potash per pot.)	
47	Without special applications..........	10.8
52.....	Without special applications.........	68.4

By examination of the results for the year 1894 with Indian corn (maize), it will be seen that no particular differences in yields are visible, other than such as would be readily attributable to the unavoidable individuality of the plants in the several pots. It should be stated also that all the plants appeared to be in good conditon throughout their entire period of growth. In 1895 all of the plants looked well throughout, except where muriate of potash was used without the addition of caustic magnesia, sodium carbonate or wood ashes (Group V). When the plants in this exceptional group were from six to ten inches high a yellowish appearance became noticeable, and for about a week it seemed doubtful if they would ever fully recover; yet a change for the better was soon visible, and in a few days they seemed to be in perfect condition, and remained so until the end of the season. It was noticeable that the plants in the pots which received wood ashes and maximum applications of caustic magnesia and sodium carbonate were larger and better developed than the others, yet the differences would hardly have attracted the attention of a casual observer; the yields obtained, however, were decidedly greater from those pots than from any of the others.

In 1896 barley was selected instead of Indian corn, in order that a greater number of plants might be grown, whereby less variation due to individuality would result. Opportunity was thereby also afforded for comparing the results from the consecutive use for three years of sulfate of ammonia in this experiment, with those from the similar use of nitrate of soda in the experiments previously described. The results of this experiment are in many respects quite striking. It will be seen that an increased yield has resulted in the case of each increase in the amount of caustic magnesia and of sodium carbonate employed. A lower yield was obtained from the smallest application of sodium carbonate than from the corresponding ration of caustic magnesia, yet whether this was incidental, or attributable to the greater solubility of the sodium carbonate, whereby some of it may have been quickly leached into the subsoil without having had time to exert its maximum effect, it is impossible to conclude. It will be seen that the yields were better where carbonate of potash had been used for three consecutive years (Group IV) than where an equivalent amount of potash in the form of muriate had been employed.[1] The residual chlorin from the muriate of potash seems in this case to have augmented the injurious action due to the residual sulfuric acid of the sulfate of ammonia, and injury was caused which could have been prevented, had sufficient basic ingredients been applied in connection with it, as is abundantly shown above. It will be noticed that there is a great discrepancy in the yields from the two plots (47 and 52) where the muriate of potash was applied without the addition of wood ashes, caustic magnesia, or sodium carbonate. In fact when the barley was about an inch and a half high, or even a little earlier, the tops were seen to be yellow, which was not the case to even a slight extent where any considerable amount of basic ingredients was applied, and this condition continued, in the case of the plants in pot 47, throughout the entire season, while those in pot 52, after languishing for three or four weeks, quite suddenly recovered. but though they made considerable subsequent growth, failed, owing to the lateness of the season, to catch up with the plants which had been vigorous from the outstart. Having thus called attention to all of the points which seem particularly worthy of attention, it now remains to consider what deductions may be drawn from the results for the three years when considered as a whole. In 1895 and 1896 the gains from the use of wood ashes, and of the largest applications of caustic magnesia and sodium carbonate, were not very dissimilar, though, considered as a whole, sodium carbonate seems to have been somewhat inferior to the others in its action in 1896. At all events, the results, taken in connection with other observations, do not indicate that these substances were chiefly beneficial, either on account of their fertilizing or physical action, but rather by virtue of their combination with the chlorin of the muriate of potash, and with the sulfuric acid of the sulfate of ammonia, whereby a further increase of acidity, or an accumulation of compounds noxious to vegetation, was prevented. That such was the function of these compounds is plainly seen by the very serious results where muriate of potash and sulfate of ammonia were used together independent of them. If it were argued that the differences observed were attributable to the fertilizing function of the calcium, magnesium and sodium, it must be evident that the vast difference in the action of the carbonate and of the muriate of potash cannot be accounted for in that way, for the reason that the quantities of actual potash were alike in both instances, as were likewise all of the other conditions. It does not seem reasonable, nor is it conceivable, that such serious physical soil conditions should have resulted in three years, from the use of muriate of potash and sulfate of ammonia, that barley would be unable to produce (as in the case of pot 47) more than from a twelfth to a thirteenth of a normal crop. In consideration of these points the only reasonable assumption which now presents itself is that the fault with the soil is a deficiency of bases, on which account the use of such fertilizers as leave residual acids is followed quickly by serious results. On the same account acid humous bodies accumulate to such an extent as to be noxious to certain plants.

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[1] A similar observation has been made by Goessmann (Eleventh An. Rpt. Mass. Agrl. Expt. Station, 1893, pp. 247-251) in greenhouse experiments with carbonate of potash and of magnesia.

Experiment D. The pots and soils employed in this experiment were exactly like those described in connection with the three foregoing ones. These pots were used in 1894, 1895 and 1896, in connection with an experiment for the purpose of ascertaining why air-slacked lime promotes the development of potato scab.[1] In 1894 and 1895 each pot received the following:

	1894. Grams.	1895. Grams.
Dried blood	21	20
Nitrate of soda	5	7
Muriate of potash	10	10
Dissolved boneblack	25	25

The quantities used in 1896 were the same as in 1895. The

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[1] R. I. Agrl. Expt. Station Bulletins Nos. 30, 1894; 33, 1895 and 40, 1896.

Fig. 3.

1. Received air-slacked lime.
2. " no lime.
3. " calcium chlorid.
4. " " sulfate (land plaster).
5. Received calcium carbonate.
6. " " oxalate.
7. " " acetate.
8. " wood ashes.

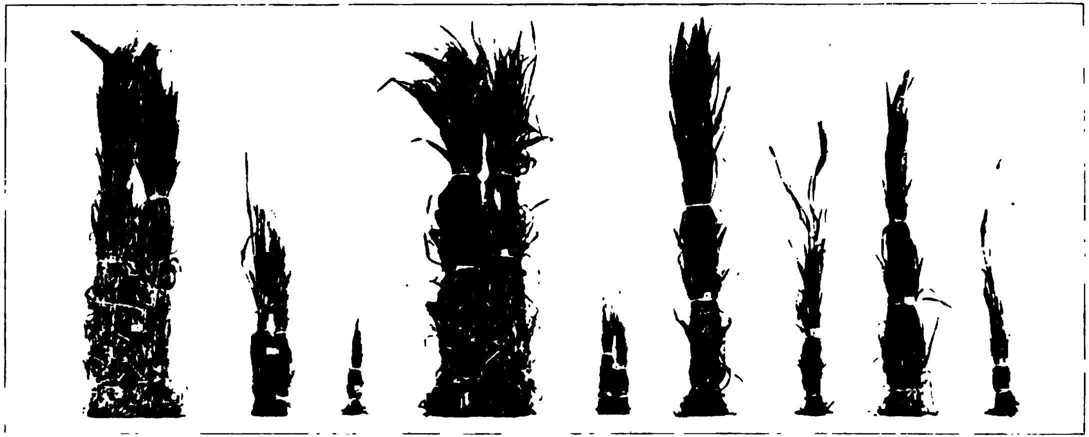

Fig. 4.—Barley.

1. Received potash, phosphoric acid and *lime*, 4 tons per acre in 1893.
2. " " and phosphoric acid.
3. " " phosphoric acid and sulfate of ammonia.
4. " " " " sulfate of ammonia and lime, 4 tons per acre in 1893.
5. " " " " " " " " land plaster equal to lime, 4 tons per acre in 1893.
6. " " " " " " " " caustic magnesia.
7. " " " " " " " " magnesium sulfate.
8. " " " " " " " " sodium carbonate, also in 1893, lime, 1 ton per acre.
9. " " " " " " " " also in 1893, lime, 1 ton per acre.

calcium compounds and wood ashes used in 1894 were applied at such a rate that the amount of calcium was equivalent in all cases to an application of two and one-half tons of air-slacked lime per acre. In 1895 further applications of these substances were made at a rate equivalent to half a ton of air-slacked lime per acre. In 1896 these compounds were omitted in order that their after-effect might be studied. In 1894 the potato vines appeared to be slightly better where air-slacked lime, calcium carbonate, calcium oxalate, calcium acetate and wood ashes were employed, than where gypsum was used, and a positively poisonous action of calcium chlorid was evident. In 1895 more striking differences became manifest, and in 1896 this was true even in a more marked degree. The following table of averages shows the general result in 1896. (*See illustration, Fig. 3.*)

NUMBER OF POTS IN THE EXPERIMENT.	FORMS OF LIME EMPLOYED IN 1894 AND 1895.	AVERAGE YIELD OF TUBERS (IN GRAMS) PER POT.
3	Air-slacked lime	522.7
3	Unlimed	179.5
3	Calcium chlorid	35.2
3	Calcium sulfate	126.2
3	Calcium carbonate	489.8
3	Calcium oxalate	507.5
2	Calcium acetate	563.3
2	Wood ashes	492.0

It will be seen from the foregoing that calcium chlorid exerted a positively poisonous action, as shown by the yield, which was far less than where no calcium compounds were applied. The average yield where calcium sulfate (land plaster) was employed was less than that without lime in any form. This may have been merely incidental, or possibly it may have been attributable to injury from residual sulfuric acid, though the data at hand are not sufficient to warrant a definite conclusion. Upon a comparison of the results where calcium compounds were omitted, and also where calcium sulfate was used, with those obtained with calcium carbonate, the great gain from the use of the latter is at once evident. Air-slacked lime changes gradually into carbonate in the soil, and in wood ashes the lime is probably practically all in the form of carbonate at the outstart. It will be seen, also, that calcium acetate and calcium oxalate affected the growth of the tubers in a decided manner. These compounds have been found likewise to be as conducive to the development of potato scab as calcium carbonate, wood ashes or air-slacked lime. In the discussions of the results in that connection, this was attributed to a change of these compounds into calcium carbonate as a consequence of the natural processes of decomposition going on within the soil. An investigation by Schmoeger[1] has recently come to our notice wherein it was conclusively shown that calcium tartrate, and calcium oxalate, under conditions analogous to those which would exist in soils, (that is, under the influence of micro-organisms), are readily converted into calcium carbonate, and there is equal reason for supposing that the same change would take place with calcium acetate. That the benefit derived from calcium carbonate, and other forms of lime which are transformed into the same in the same soil, was attributable solely to a fertilizing function of the lime does not seem possible, for otherwise a similar benefit would have been expected from land plaster, which, unlike calcium chlorid, is not considered as being a plant poison. If the benefit were due solely to the flocculating power of the calcium carbonate, which must have been great to effect such a change, then it would have been probable that plaster would have been of some benefit, for Sachsse and Becker[2] found that plaster was ineffective only where the effect of lime was small. It seems, therefore, highly probable that the peculiar benefit from calcium carbonate was due chiefly to its ability to neutralize the acid compounds pre-existing or produced in the soil by the decomposition of plant residues, as well as the acid residues from the manures applied.

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[1] Ber. d. d. chem. Gesell. 12, 1879, p. 755.

[2] Die landw. Vers. Sta. 43, p. 22.

Experiment E. The pots in which this experiment was conducted were like those employed in experiments A, B, C and D, and were likewise surrounded by soil to within two or three inches of their tops. The subsoil came from the same place as that used in all of the foregoing experiments, 154 pounds having been put into each pot, and upon this 100 pounds of surface soil from the unmanured plot, No. 00, of the so-called co-operative acre of which the "soil test" plots form a part. These pots were filled, and experiments begun in them, in 1893, or one year before those heretofore described. It should be noted that an ill effect from the use of sulfate of ammonia was observed in these pots the first season, while in the case of the pots filled a year later (experiment C), with soil from the same plot, the results were excellent the first year, a temporary ill effect only was noticeable the second year, and it was not until the third year that a strongly marked ill effect was produced. This must have been due to irregularities in the previous treatment of the soil, or to naturally existing differences. In both 1893 and 1894 each manured pot received 7.36 grams of muriate of potash, and 22.07 grams of dissolved boneblack, and in 1895 and 1896 the quantities were 10 and 25 grams respectively. Sulfate of ammonia containing 20 per cent. of nitrogen was applied at the rate of 13.25 grams in 1893, and, owing to the differences in the composition of the sulfate of ammonia used, the quantity was varied sufficiently each year to maintain the amount of nitrogen equivalent to that employed in the first application. For the purpose of ascertaining whether the beneficial action of air-slacked lime, heretofore observed, was probably due to its neutralizing or manurial function, trials were made of like amounts of lime in the form of air-slacked lime, and as land plaster (gypsum), with the following results. None was applied in the years subsequent to 1893. (*See illustration, Fig. 4.*)

No. of Pot.	Forms and Amounts of Lime Applied in 1893.	Indian Corn.[1] (Grams.) 1893.	Oats.[2] (Grams.) 1894.	Rye.[1] (Grams.) 1895.	Barley.[1] (Grams.) 1896.
	Pots without Sulfate of Ammonia.				
23	Limed	117.3	55.8	56.7	73.1
24	Limed	120.8	60.2	44.6	83.9
20	Unlimed	64.5	17.2	4.2	11.5
27	Unlimed	69.1	19.4	3.8	9.8
	Pots with Sulfate of Ammonia.				
16	Unlimed	9.2	14.5	1.2	*
18	Unlimed	8.0	7.1	0.6	*
25	Unlimed	20.6	14.0	1.0	2.3
15	Air-slacked lime, 1 ton per acre	171.3	67.8	0.8	*
22	Air-slacked lime, 1 ton per acre	204.1	62.9	2.1	5.7
17	Air-slacked lime, 4 tons per acre	185.7	72.3	106.9	116.1
19	Air-slacked lime, 4 tons per acre	187.8	72.9	108.4	120.8
26	Air-slacked lime, 4 tons per acre	203.4	83.1	97.5	118.6
1	Plaster equivalent to 4 tons of air-slacked lime per acre	52.9	38.9	1.6	4.5
8	Plaster equivalent to 4 tons of air-slacked lime per acre	20.0	16.0	0.8	3.4
	Note.—The Indian corn was allowed to ripen, the oats, rye and barley were cut before maturing their seed.				

From the foregoing table it will be seen that no results are given for pots 16, 18 and 15, for 1896. This is for the reason that these pots were employed that year for trials of caustic magnesia, magnesium sulfate (Epsom salts) and sodium carbonate, the results of which will follow. It is at once noticeable that the yields each year were smaller, where sulfate of ammonia was used in addition to muriate of potash and dissolved boneblack, than where it was omitted. Where air-slacked lime at the rate of one ton per acre was used, the results were apparently as good the first year as where it was applied at the rate of four tons per acre. The second year, however, it appeared to fall behind somewhat, and the third and fourth years little or no further benefit from it was observable. Where air-slacked lime was applied at the rate of four tons per acre the results for the four years have been good, and it will be seen by comparison with those pots which received the same amount of potash, phosphoric acid and lime, but no nitrogen (23 and 24), that the sulfate of ammonia proved of great benefit. It is evident that plaster (calcium sulfate), though it alleviated apparently in a slight degree the ill effect of the sulfate of ammonia, was not sufficiently effective to render the yields from the pots which received nitrogen equal to those which did not. It must be obvious that the beneficial action of the lime in this instance could not be attributable to its fertilizing action solely, regardless of other considerations, for otherwise more marked results should have been noticeable from the application of plaster. Had the beneficial action of the lime been due solely to an improvement of the physical condition of the soil, it would have been expected that plaster would have acted more favorably in that direction than it did, and it would not have been expected that the wonderful benefit from the application of one ton of air-slacked lime per acre would so suddenly have ceased. The most, and in fact the only, reasonable explanation which at present presents itself, is that the soil was deficient in bases, owing to which the products of the decomposition of plant residues remained largely in an acid state. This condition is probably aggravated by the use of manures like sulfate of ammonia, which leave an acid residue, and the beneficial action of the air-slacked lime seems to be attributable to its having served as a neutralizer, or, in other words, to its action in overcoming or decreasing the sourness (acidity) of the soil.

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[1] Total weight after air drying for several weeks in the laboratory.

[2] Absolutely dry.

* Received special treatment in 1896, and reported upon elsewhere.

In order to still further test this question, one of the pots which had received lime at the rate of one ton per acre in 1893, received in 1896, an application of 33.18 grams of pure sodium carbonate, which was equivalent to 1800 pounds per acre. The results from the two pots are as follows: (*See illustration*, *Fig. 4.*)

No. of Pot.		Barley.[1] (Grams.)
2......	Without sodium carbonate..........	5.7
15.	With sodium carbonate........	37.1

The advantage from the use of sodium carbonate (soda ash) cannot be attributed solely to its direct or indirect fertilizing action, particularly in view of the fact that a generous application of potash had taken place; and, considered in connection with comparative trials of sodium and potassium carbonates in another place in this Report,[2] it need merely be remarked that the action seems to be most readily explained upon the same ground as that of air-slacked lime. With the hope of throwing still further light upon this matter, one of the three pots (see table page 312) which had received annual applications of sulfate of ammonia, without either air-slacked lime or plaster, was treated with 38.1 grams of caustic magnesia, and another with 120 grams of magnesium sulfate[3] (Epsom salts).

The following shows the results obtained: (*See illustration*, *Fig. 4.*)

No. of Pot.		Barley.[4] (Grams.)
25......	Without further applications.	2.3
16......	With magnesium sulfate..........	10.5
18	With caustic magnesia	76 3

[1] Dried the same as that mentioned in the foregoing table.

[2] See pp. 221 to 237.

[3] The former contained 96.31 per cent. of magnesia (MgO) and the latter 16.06 per cent.

[4] Dried the same as that mentioned in the foregoing table.

Magnesium sulfate had evidently been of some slight value, though perhaps chiefly as a fertilizer, and not to any decided extent, in diminishing the ill-effect of the sulfate of ammonia. The much greater effectiveness of the caustic magnesia seems to find its explanation in the same manner as that of the air-slacked lime, where the latter was compared with plaster. The results are indeed too striking to require further comment.

Experiment F. This experiment was conducted for two purposes, namely: with the hope of determining if soda is of any value as plant food, in connection with a generous supply of potash; and, also, if plaster (calcium sulfate) is capable of exercising a beneficial influence equal to that exerted by air-slacked lime. This field experiment was begun in 1895. Each of the six plots has received annually like amounts of potash, phosphoric acid, nitrogen and magnesia. The plots were divided into three pairs, one of which received no further treatment, another air-slacked lime, another plaster (calcium sulfate) at a rate furnishing the same equivalent of lime (calcium oxid) as the air-slacked lime. The liming was not repeated in 1896. One plot of each pair received its nitrogen and potash in the form of nitrate of potash, and the other in the form of nitrate of soda and muriate of potash. Each plot was divided in 1895 into two equal parts, table beets having been grown upon one side and mangel wurzels upon the other. The results were practically the same with both varieties of beets: the product upon the unlimed plots was trivial, that upon the plaster plots was good, while upon the air-slacked lime plots by far the best results were obtained.[1] In 1896 red clover was sown upon one side of the plots, and barley and timothy upon the other. The results with barley and red clover are given in the following table: (*See illustrations, Figs. 5 and 6.*)

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[1] Eighth An. Rpt. R. I. Agrl. Expt. Station, pp. 268–278.

NAMES OF CROPS.	AIR-SLACKED LIME.		PLASTER. (Calcium sulfate.)		UNLIMED.	
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
	Nitrate of potash.[1]	Muriate of potash and nitrate of soda.	Nitrate of potash.	Muriate of potash and nitrate of soda.	Nitrate of potash.	Muriate of potash and nitrate of soda.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
Barley (grain and straw)..........	28.0	28.5	22.0	16.0	6.0	6.5
Barley (grain)....	8.3	6.5	6.5	4.5	1.5	3.0
Clover (green)....	66.8*	120.3	120.0	124.3	119.8	134.5

There was a marked difference in the growth of the barley from the outstart, the field observations having been in full accord with the above result. It is evident, in connection with the barley, that while much benefit was obtained from the plaster, that from the air-slacked lime was much greater. In the case of the clover, on the contrary, that on one of the air-slacked lime plots (No. 1) did not seem to start well, which was attributed to the fact that the surface of the ground on that plot was much drier than any of the others, in consequence of which it was supposed that some of the seed was blown away by high winds. This could not have resulted so easily on the other plots, where the ground was more moist. Had a loss of seed not resulted in this case it would have been expected that more of it would have germinated later, which was not the case. It was of interest to note that the clover looked as well on the unlimed plots as on the others, from the outstart. Towards the close of the season a few of the plants on these plots seemed

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[1] Each plot received 800 pounds per acre of dissolved boneblack, and 400 pounds of sulfate of magnesia. The nitrogen and potash applied to each plot were equivalent to that furnished by 7.7 pounds of nitrate of potash, containing 13.89 per cent. of nitrogen and 46.49 per cent. of potash.

*After seeding to clover an unusually high wind prevailed, and it is supposed that, owing to the slightly dryer condition of the soil on this plot, more seed was carried off by the wind, which would account for the differences observed in the stand.

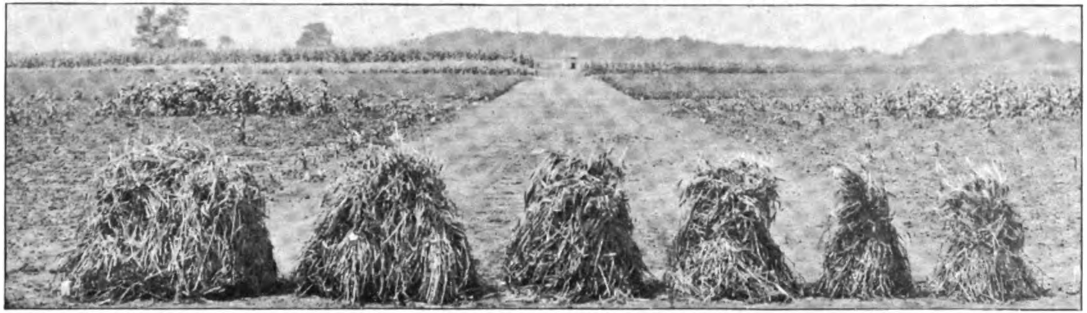

FIG. 5.—BARLEY.

Air-slacked lime. *Land plaster.* *Unlimed.*

1 2 3 4 5 6

1, 3 and 5. Received nitrate of potash.
2, 4 and 6. " nitrate of soda and muriate of potash.

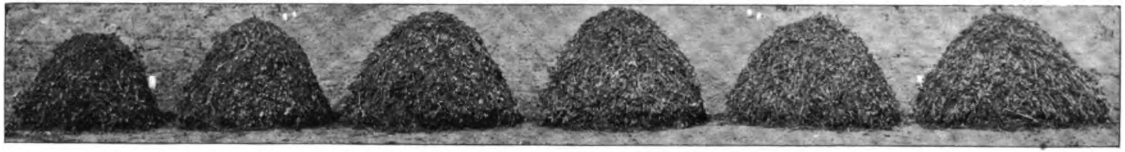

FIG. 6.—RED CLOVER.

Air-slacked lime. *Land plaster.* *Unlimed.*

1 2 3 4 5 6

1, 3 and 5. Received nitrate of potash.
2, 4 and 6. " nitrate of soda and muriate of potash.

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to be turning slightly yellow, while those where air-slacked lime was used maintained their green and vigorous appearance. This good result with clover seems at first very surprising, in view of the action of the barley, and particularly in consideration of the almost total failure of the beets in 1895. However, upon looking up the records of the results secured with clover, barley and beets (see previous Reports of this Station), upon plots 27 and 29, it will be seen that beets were most benefited by lime, followed in order by barley and clover. From this it seems possible that the soil may naturally have been in a condition still suitable for clover, yet not quite adapted to barley, and wholly unfit for beets; it is probable, however, that clover would soon fail on the unlimed plots, provided such fertilizers as leave acid residues were used. The barley, like the beets in 1895, showed a decided advantage from the use of plaster, which may be attributed to a fertilizing or physical effect, or a combination of the two, and it might be argued that the greater effect of the air-slacked lime was due to the same cause, yet, in view of the differences in the beets in 1895, which appear to be too great to be explainable upon this basis, it seems probable that the action of the air-slacked lime in this experiment was attributable in a considerable degree to its neutralizing action.

SUMMARY.

When treated alike in other respects an ill effect from continuous applications of sulfate of ammonia, upon the Experiment Station soil, was found to result, eventually, in all cases, while this was not the case where an equivalent amount of nitrogen, in form of nitrate of soda, was employed. The ill effect of sulfate of ammonia can be prevented altogether, by the employment in connection with it of sufficient potassium carbonate in place of crude potassium chlorid (muriate of potash), or by the employment of wood ashes, air-slacked lime, sodium carbonate (soda ash) or caustic magnesia. Magnesium sulfate (Epsom salts) was not found equal in this respect to caustic magnesia; the same was true in a more marked degree of calcium sulfate (gypsum or land plaster) as compared with air-slacked lime. Calcium sulfate failed to exert the same beneficial influence upon the growth of potatoes as calcium carbonate, wood ashes, air-slacked lime, calcium acetate and calcium oxalate; all of which latter substances, if not already composed of or containing calcium carbonate, are changed into that form within the soil.

These observations lead to the conclusion that aside from a beneficial, manurial or physical influence which air-slacked lime, wood ashes, calcium carbonate, potassium carbonate, sodium carbonate and caustic magnesia may have had, they were probably useful, in a high degree, on account of a natural deficiency of bases in the soil, and their ability to correct acidity (sourness) naturally existing or induced therein by artificial methods of cropping and manuring.

THE ARMY WORM IN RHODE ISLAND.

CHARLES O. FLAGG AND GEORGE WILTON FIELD.

In the early part of July complaints began to be made, by farmers, in various parts of the State, regarding the presence in greater or less numbers of a destructive worm in fields of grass or grain. In most cases it appeared in meadows seeded to grass the previous autumn, or in fields of spring sown barley or oats. When discovered it was usually present in such numbers as to seriously interfere with or entirely check the growth of crops, and in some cases even devoured the growth already made. Investigation quickly determined the intruder to be the so called "army worm" (*Leucania unipunctata*, Haw.) which, from time to time, at irregular intervals, has proved destructive, especially to grass and grain crops, in various sections of the United States.

A field of about four acres, at the west end of the college farm, had been seeded to grass in the autumn of 1895, and in the early spring presented a very even catch, and green, vigorous, thrifty appearance, promising an abundant crop of hay. As the season progressed, however, growth appeared to be slow, feeble and irregular, while numerous weeds pushed their heads above the short grass, and the early spring promise of a bountiful crop rapidly dwindled as haying time approached. On July 13 the whole field was found infested with the army worm, and the nearly mature caterpillars were migrating to an adjoining field, and crossing the highway into the grass lands of the Experiment Station. A deep furrow was immediately plowed along the roadside, and against the corn field, turning the furrow *toward the infested field.* The caterpillars have no difficulty in creeping over the freshly turned earth and into the furrow, but cannot climb up the perpendicular bank left by the "landside" of the plow. The furrow should be six or more inches deep, and the "landside" perpendicular to present an effectual barrier. It should be carefully inspected after plowing, and all stones or clods of earth which have rolled back into the furrow removed, and any imperfections in the perpendicular bank corrected by cutting out with a spade. Overhanging grass roots or stems should be removed, or they will be utilized as suspension bridges by the worms. In addition to plowing the furrow, the infested field was thoroughly rolled with a heavy iron roller. Comparatively few worms collected in the bottom of the furrow, and nothing further was done. It has been found necessary in some instances, when the army worm has been present in such numbers as to fill the furrows, to destroy them by putting coal-tar, crude petroleum, or wheat bran mixed with Paris green, along the furrows. September 2d, the forty-eight plots of Hungarian grass, which was sown as a second crop after oats in the Soda-Potash Substitution Experiment, were found to be infested with the army worm. Although hardly half grown, the crop was immediately cut and the field rolled, as in the previous case, and no damage was done to adjoining crops. Early in October, army worms were seen in considerable numbers in a field of grass near the college buildings, but no appreciable damage was done by them.

A circular letter was sent to one or more persons in each of the thirty-six cities and towns in the State, and twenty-eight replies were received, of which thirteen were from Providence county, eight from Newport county, four from Washington county, two from Kent county, and one from Bristol county. All the correspondents who replied, with three exceptions, reported the appearance of the army worm in their vicinity. The exceptions were the two replies from Kent county, and one in the western part of Washington county.

Providence County. In the thirteen replies received, the following named crops were reported as damaged: oats, in nine cases; barley, five; Hungarian, four; corn, three, and grass, two. Hungarian, especially where sown a little late, was reported as entirely destroyed. In one instance coal-tar was used in a furrow for protection, and a trench two feet deep was dug, to protect a cornfield, in another instance. One or two fields were plowed, and the worms deeply buried. One man destroyed the worms by burning over the grass stubble. Two more reported that chickens were very fond of the caterpillars. In one case, 400 chickens lived for some time upon them, and in the other case, 250 chickens preferred them to a grain diet.

Newport County. The eight replies received name the following crops as damaged: oats, in seven cases; barley, three; and millet, grass, and corn, one each. Portsmouth and Little Compton, apparently, suffered from a more widespread attack than other sections of the county. In the north half of Conanicut island (Jamestown) no worms were seen, while some damage was done on the south part. On Block Island, worms appeared in a score or more of places, doing some damage to oats and barley, but less this time than about ten years ago. One instance is stated where pigs broke into an oat field and completely exterminated the army worms, while the damage done by the pigs to the oat crop was estimated at only four per cent.

Washington County. Four replies were received. In one case none had been seen. In another case an area of only about one-fourth of an acre, in a field of oats of seven and a half acres, was infested. Another reported them not sufficiently numerous to cause any damage, and the fourth stated that, in some part of nearly every field of oats and barley, army worms could be found. Only one case of damage, late in the season, was reported. Crow Blackbirds were reported as feeding upon them. An instance is cited where the army worm has appeared in one certain field whenever oats or barley have been grown there—five different times. Three years ago, when this same field was in grass, a part of it was injured by the army worm.

Kent County. As before stated, only two replies were received from this county, and neither correspondent had any knowledge of the appearance of the army worm in his vicinity, but, from newspaper and other reports, we are certain that the county was not entirely exempt from the visitation of the army worm.

Bristol County. Occasional localities were found infested by the army worm, but in such limited numbers as to make the damage merely nominal.

Correspondents name numerous dates when the army worm has been troublesome in this State. The earliest date mentioned is 1853. In 1861, from the frequency with which it is mentioned, there appears to have been quite a general outbreak, and, in some portions of the State, none have been seen since. In other portions quite severe visitations occurred about ten years ago. Since Dr. Riley and other entomologists have thoroughly solved its life history, we know that, in all probability, it is ever present in our fields in limited numbers, living a life very similar to that of one of the "cut worms," and it is only through peculiar meteorological conditions that it increases to such numbers that the food supply is consumed, and the abnormal characteristic of marching in armies is presented. Serious attacks of army worms are said to follow a year of drouth, but, as every year of drouth is not succeeded by a plague of army worms, some other conditions must have a controlling influence. The following account of the life history of the army worm, and suggestions regarding preventive measures, has been prepared by Dr. George Wilton Field.

LIFE HISTORY OF THE ARMY WORM.

The life history of the army worm (*Leucania unipunctata*, Haw.) first began to be known in 1855, and was described in the Ohio Agricultural Report of that year.

Many important points remained undiscovered until studied by the late Dr. C. V. Riley. He ascertained, among other facts, that "the eggs are laid in tame or wild grasses, or in grains along the inner base of the terminal blades where they are yet doubled, or between the stalk and its surrounding sheath. The rank tufts of grass, caused in pastures by the droppings of cattle and sheep, are preferred by the moth for oviposition, and in the tufts the oldest and toughest stalks; and in grain fields, also, the ranker growths caused by an accumulation of manure at some one spot, or the previous existence of some fodder heap or the like, are preferably chosen. Early in the season moths lay their eggs, by preference, in the cut straw of old stacks, or even in old bits of corn stalk on the ground, and hundreds of eggs are thrust under the sheath or epidermis. When exceptionally numerous, the moths will lay the eggs without concealment, even on plants (e. g. clover) which ordinarily are not relished by the caterpillar. The eggs are whitish spheres about ⅟50 in. in diameter. When almost ready to hatch it appears darker. A female moth produces 500–700 eggs.

If the eggs were laid in a green grass blade, the larvae, on hatching, feed for a time on the fold of the leaf. When hatched in the stubble they remain sheltered therein for three or four days, issuing at night to feed, but going back for shelter. In this stage they are whitish in color, and walk like loopers, and when disturbed drop, suspended by a silken thread, or curl up. They ordinarily feed in the manner of cut worms. The young are difficult of detection, and of a different color from the full grown worm. It is only when present in such numbers that migrations are necessary to secure food, that they attract attention by the "armies."

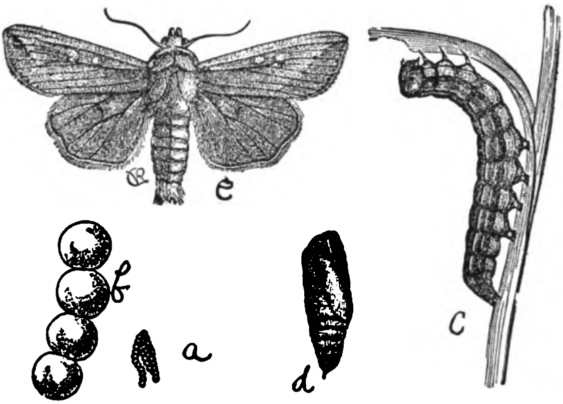
The common name is thus seen to be derived from an abnormal habit. When full grown (about four weeks after hatching) the larva is a smooth cut-worm-like caterpillar, 1½ in. long, generally of a dark gray or dingy black color, with three narrow yellowish stripes above, and a broader or slightly darker one on each side, thinly clothed with short hairs (to be seen with a lens), which are longer and somewhat thicker on and about the head. The head is of a polished honey-yellow color, with a network of fine, dark brown lines, and a black line on the front like the letter V reversed."

These worms go into the ground, under roots of grass, under stones or rubbish, there shed the skin and pass into the pupa or chrysalis stage. In this condition they are about $\frac{3}{4}$ in. long; at first light brown in color, soon changing to deep chestnut brown. From this the moths emerge in about two weeks. There are probably two or three broods every year in the more northern States. The last brood of the season hibernate as half grown caterpillars, hiding under any convenient shelter, where they remain in a sluggish condition until spring. The moths from this brood hatch very early, and, under favorable conditions, produce the vast armies too familiar to man.

The moth measures about $1\frac{1}{2}$ in. from tip to tip. General color of the body and front wings is a peculiar reddish gray, or fawn color. Near the middle of each front wing are two more or less irregular lighter patches, each of which is seen, on closer study, to be made up of three smaller spots. Along the side margins of both pairs of wings there is a fringe of feathery scales, immediately inside of which, on each of the front wings, is a row of blackish dots. The hind wings are more grayish, with less of the reddish tinge.

NATURAL ENEMIES.

Fortunately, like every other injurious animal, the army worm has a host of natural enemies. The largest of these are the robin, bluebird, blackbird, bobolink, meadow lark, pigeon-woodpecker (*Colaptes auratus*), and others, which destroy large numbers. A black predaceous ground beetle also does valiant service in thinning the ranks. But most important of all are the tiny two-winged *Tachina* and the four-winged *Ichneumon* flies, which pierce the skin of the caterpillar and lay their eggs in the soft organs below.



The Army-worm: *a*, egg-mass, natural size; *b*, eggs, magnified; *c*, full-grown larva; *d*, pupa; *e*, moth. (After Riley.)

The stages in the development are shown in the above cut, which was furnished through the courtesy of the New Hampshire College Agricultural Experiment Station, as used in their Bulletin 39, September, 1896.

By comparing the figures with the descriptions of the caterpillar (p. 323), chrysalis and moth (p. 324), specimens can be readily identified.

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The flies' eggs hatch, and the maggots feed upon the vitals of the caterpillar, ultimately destroying it.

Many moths are entrapped in spiders' webs, or destroyed in the electric arc lights. The large ground spider (*Epeira*) feeds upon the caterpillars. There seems to be evidence, too, that millions of the caterpillars are destroyed by an infectious disease, a sort of insect cholera, whose germs attack the army when the numbers are excessive. These natural checks undoubtedly are the cause of the rapid disappearance of the pest.

PREVENTIVE MEASURES.

Artificial aids may add much to prevent the destructive spread of this insect. The devices best known are: (1) If confined to a limited area, the infested crop may be cut. The worms remain beneath this shelter for two or three days. As soon as the herbage is dry enough, it should be burned. (2) They may be trapped in ditches and trenches; "The device of stopping the armies of traveling worms by means of ditches and trenches, occurred to the earliest sufferers from their depredations. In the New Hampshire outbreak of 1770, Mr. Powers tells us[1] that the inhabitants "dug trenches around their fields a foot and a half deep, hoping this might prove a defence; but they soon filled the ditch, and the millions that were in the rear went over on the backs of their fellows in the trench, and took possession of the interdicted food. The inhabitants then adopted another expedient to save those fields yet standing. They cut a trench as before; then took round and smooth sapling sticks, of six or eight inches diameter, and six or eight feet in length, sharpened them to a point, and with these made holes in the bottom of the ditch, once in two or three feet; and as their meadows were bottom lands, they experienced no difficulty in extending these holes to two or three feet in depth below the bottom of the trench. The sides of these holes were made smooth by the bar or lever which made the holes, and as soon as the worm stepped from the precipice, he ended at the bottom, and could not ascend again; indeed, he was soon buried by his unfortunate fellows who succeeded him in his downfall. Now those who made these holes to entrap their invaders, went around their fields and plunged these pointed levers into the holes filled with worms, and destroyed every one of them at a single thrust." Similar methods of fencing off the worms have often been employed to good advantage since. The side of the furrow or trench next the field to be protected should incline obliquely, so that the upper part will be nearer the side toward the worms than the lower part, thus rendering its ascent more difficult. In cases where holes are not dug in the bottom of the trench to trap the worms, they may be killed by dragging boards or small logs along, or by strewing the trench with straw from time to time, and then burning it." (3) Spraying with kerosene emulsion. "This is prepared by adding 2 gallons of kerosene to 1 gallon of a solution made by dissolving ½ pound of hard soap in 1 gallon of boiling water, and churning the mixture by forcing it back into the same vessel through a force-pump with a rather small nozzle, until the whole forms a creamy mass, which will thicken into a jelly-like substance on cooling. The soap solution should be hot when the kerosene is added, but of course must not be near a fire. The emulsion thus made is to be diluted before using against the army worm, with five or six parts of water to one part of emulsion. The amount of dilution varies with different insects. Soft water or rain water should be used in diluting. If this cannot be obtained, add a little lye or bicarbonate of soda. It should be applied with a spray pump or nozzle."[1] (4) Dust with a poison (e. g. Paris green) where it can be done without danger to live stock, by means of an insecticide bellows, when the dew is on. (5) Most important of all, the fields infested should be burned in the autumn or early spring, in order to kill the hibernating caterpillars. The burning should be thorough, and should include rubbish heaps, hedge rows, etc.

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[1] Bull. 39, New Hampshire Agrl. Expt. Sta., p. 72-73.

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[1] Bull. 39, New Hampshire Agrl. Expt. Sta., p. 72.

TRIAL OF PHOSPHATES.

CHAS. O. FLAGG AND G. M. TUCKER.

This experiment is designed to throw some light upon the question of the practical values of the several different sources of phosphoric acid used as a fertilizer. The same weight and value of nitrate of soda and muriate of potash is used upon each of the twenty plots involved in this experiment, and the same money value of phosphoric acid, in nine different forms, is applied to as many different pairs of plots, and in addition one plot in each pair received, in 1894, air-slacked lime at the rate of one ton per acre. No further application of lime has been made. This experiment was begun in 1894, and, as originally planned and reported,[1] included only eight kinds of phosphates, each of which required two plots, and two additional plots, used as "checks," which received no phosphoric acid, made the original number used in the experiment eighteen. They are numbered 51 to 58 inclusive, on the plan of Experiment Station grounds, found as a frontispiece to this Annual Report. In the spring of 1895 a phosphate was found in the market, under the name of "Double Superphosphate," containing a very high percentage of available phosphoric acid (44.64), and the total amount reached over forty-five per cent. (45.50).[2] It was thought best to include this phosphate in the experiment, and therefore two plots, Nos. 69 and 70, on the east side of the eighteen already used for a year in this work were added to the number so that now twenty plots, Nos. 51 to 70 inclusive, are covered by the experiment. Of these, all the odd numbers, ten on the north side of the driveway, have been limed, and all the even numbers on the south side are unlimed. In 1893, plots 69 and 70 were planted to Indian corn without fertilizer, as was the case with the other plots, and in 1894 these two plots were again planted to corn without fertilizer, and the yields are here given for comparison with the yields in 1893 of the other plots used in the experiment, and published on page 123 in the Annual Report for 1894.

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[1] See Seventh An. Rpt. R. I. Agl. Expt. Sta., 1894, p. 122.

[2] In 1896 the double superphosphate used had 41.58 per cent. *soluble* phosphoric acid, and the *total* per cent. was 49.21.

Table showing the yields of Indian corn in 1893 and 1894, on plots 69 and 70, before they were included in the phosphate experiment.

No fertilizer had been applied to them for more than four years preceding 1894.

Plot Number.	Total Weight of Corn and Stover.	Weight of Stover.	Weight of Corn.	Weight of Large Ears of Corn.	Weight of Inferior Ears of Corn.	Ratio of Stover to Total Corn.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
69. Crop of 1893..	220	94.75	125.25	105.5	19.75	1:1.32
70. Crop of 1893..	250	111.00	139.00	114.5	24.50	1:1.25
69. Crop of 1894..	315	110.00	205.00	102.5	102.50	1:1.86
70. Crop of 1894..	295	143.00	152.00	76.5	75.50	1:1.06

The plots are separated by paths three feet wide, and are each in size, 30 x 193.6 feet, equal in area to two-fifteenths of an acre, all of which is fertilized at the rate per acre determined upon. When the crop is harvested, three feet in width along each side, and 6.05 feet across each end is cut away and discarded, the area remaining (24 x 181.5) being just one-tenth of an acre. By this arrangement, which applies to all of our permanent plots, variations due to the influence of more room, air and sunshine, on *outside rows*, are eliminated, and true field conditions secured. The per acre calculations are all based upon the crop produced upon the interior tenth acre.

THE OAT CROP OF 1895.

Following the corn crop of 1894 it was decided to sow oats in the spring of 1895, and seed the plots to grass in September. The grass seed might have been sown with the oats in the spring, and thereby saved the plowing and working necessary to the operation of seeding in the fall, but we wished to avoid any interference with results through the possible lodging of the oat crop, and consequent smothering of the grass seeding. Results justified the wisdom of the course adopted, as the oats lodged badly on a number of the plots.

The plots were plowed May 2d, with a Syracuse Sulky Swivel plow, to a depth of about six inches, and the furrows levelled with a harrow. The fertilizer, previously carefully weighed and mixed for each plot, was evenly applied broadcast, and thoroughly harrowed in. Nitrate of soda was applied to all the plots, at the rate of 401 lbs. per acre, costing at $46 per ton, $9.22. Muriate of potash was also applied to all alike, at the rate of 240 lbs. per acre, costing at $42 per ton, $5.04. The money value of the various forms of phosphoric acid applied was $6.60 per acre, based upon an application of 600 lbs. dissolved boneblack, costing $22 per ton, delivered at Kingston. Thus the total cost of fertilizers per acre was $20.86 for all the plots excepting Nos. 67 and 68, which received no phosphoric acid. The following table gives the analyses of the forms of phosphoric acid used, with two exceptions, and also the cost per ton, number of pounds applied per plot, and rate per acre.

MATERIALS USED TO SUPPLY PHOSPHORIC ACID.	Cost per ton delivered at Kingston.	Lbs. per plot purchased for $0.88.[1]	Lbs. applied per acre.	ANALYSES.				
				Phosphoric acid.				
				Per cent. soluble.	Per cent. reverted.	Per cent. insoluble.	Total percentage.	Per cent. nitrogen.
Dissolved boneblack......	$22.00	80.0	600	11.31	5.06	3.47	19.84	....
Dissolved bone...........	24.00	73.3	550	.....	.....	....	......	..
Dissolved phosphate rock.	11.00	160.0	1200	12.69	1.82	.82	15.33	....
Fine ground bone........	30.00	58.5	439	.06	20.76	6.29	27.11	2.05
Slag meal...............	20.00	88.0	660	.00	8.09	9.91	18.00	...
Floats.......	14.00	125.5	941	.00	1.70	25.75	27.45	...
Raw alumina phosphate..	25.00	70.5	529	....	.....	. .	35.43	...
Ignited alumina phosphate	40.00	44.0	330	.....	.....	......	......	....
No phosphoric acid.	....	......	....	... .	. ..	......	......	....
Double superphosphate...	42.50	41.5	311	44.64		.86	45.50	....

The oats used for seed were grown on the Station farm from seed treated with hot water, and were free from the germs of smut. They were sown broadcast, at the rate of two bushels per acre. Thinner seeding would perhaps have rendered them less liable to lodge on some of the plots. The ever present "charlock" (*Brassica sinapistrum*), so troublesome in this section of the State wherever oats are sown, required hand weeding on all the plots. The oats germinated very evenly on all the plots, but made a more rapid and vigorous growth on the limed plots during the first three weeks. A marked difference was seen in the color, which was noticeable to a considerable distance, the oats on the limed plots being of a rich, dark green color, while those across the driveway, on the unlimed plots, were more or less yellow, and less vigorous in appearance. This was not true to so great an extent where certain forms of untreated or *insoluble* phosphates, fine ground bone, slag meal and floats were used without lime, as in the case of the *soluble* phosphates. In fact the plot which presented the most yellow appearance was No. 70, where double superphosphate without lime was used. As the weather became warmer this marked difference in the color gradually became less apparent.

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[1] Each plot also received an application of nitrate of soda at the rate of 401 lbs. per acre, and of muriate of potash at the rate of 240 lbs. per acre.

Heavy storms, about the time the oats were heading, lodged them badly on plots where the growth had been most vigorous, and where all indications pointed to a large yield. All oat growers know that after oats lodge the heads generally fail to fill with grain, and even the growth of straw is lessened, and for this reason the crop produced on the various plots, both of grain and straw, should not be taken as an indication of the comparative value of the fertilizers used. Had there been no severe storms, so that a normal growth on all the plots could have reached perfection, undoubtedly some of the plots, where the oats, because of especially vigorous growth, lodged over the whole area, would have produced a much larger yield.

The following table gives the weights of straw and grain per plot and per acre, the estimated per cent. of area on each plot where the oats had lodged, and the gain or loss in the limed and unlimed series attributable to the application of the various forms of phosphoric acid.

TRIAL OF PHOSPHATES. OAT CROP OF 1895.

MATERIALS USED TO SUPPLY PHOSPHORIC ACID.	Lbs. applied per acre.	LIMED.*						UNLIMED.						Lbs. gain (+) or loss (—) per acre on limed plots compared with plot 67.		Lbs. gain per acre on unlimed plots compared with plot 68.	
		Number of plot.	Estimated per cent. lodged August 7.	Lbs. of oats per plot.	Lbs. of oats per acre.	Lbs. of straw per plot.	Lbs. of straw per acre.	Number of plot.	Estimated per cent. lodged August 7.	Lbs. of oats per plot.	Lbs. of oats per acre.	Lbs. of straw per plot.	Lbs. of straw per acre.	Grain.	Straw.	Grain.	Straw.
Dissolved boneblack......	600	51	90	118.00	1180.0	566.00	5660.0	52	50	95.75	957.5	384.25	3842.5	+715.0	+1295.0	612.5	987.5
Dissolved bone............	550	53	100	95.50	955.0	919.50	9195.0	54	100	100.50	1005.0	479.50	4795.0	+490.0	+4830.0	660.0	1940.0
Dissolved phosphate rock..	1200	55	100	103.00	1030.0	619.00	6190.0	56	100	113.25	1132.5	796.75	7967.5	+565.0	+1825.0	787.5	5112.5
Fine ground bone.........	439	57	100	86.50	865.0	583.50	5835.0	58	100	84.00	840.0	646.25	6462.5	+400.0	+1470.0	495.0	3607.5
Slag meal.............	660	59	100	93.75	937.5	646.25	6462.5	60	100	90.75	907.5	529.25	5292.5	+472.5	+2097.5	562.5	2437.5
Floats..................	941	61	100	70.00	700.0	480.00	4800.0	62	100	75.75	757.5	444.25	4442.5	+235.0	+ 435.0	412.5	1587.5
Raw alumina phosphate...	529	63	50	60.75	607.5	409.25	4092.5	64	00	49.75	497.5	370.25	3702.5	+142.5	— 272.5	152.5	847.5
Ignited alumina phosphate.	†330	65	50	40.50	405.0	279.50	2795.0	66	00	52.50	525.0	357.50	3575.0	— 60.0	—1570.0	180.0	720.0
No phosphate...........	...	67	50	46.50	465.0	436.50	4365.0	68	00	34.50	345.0	285.50	2855.0	...	...	...	...
Double superphosphate....	311	69	80	82.00	820.0	498.00	4980.0	70	5	79.50	795.0	330.50	3305.0	+355.0	+ 615.0	450.0	450.0

* Air-slacked lime applied in 1894 at the rate of one ton per acre.
† Plots 65 and 66 by accident received 198 lbs. per acre more ignited alumina phosphate in 1894 than should have been applied.

It will be noticed that on the unlimed plots in three instances, plots 64, 66 and 68, the oats did not lodge in any degree; these included the application of both forms of alumina phosphate and the one to which no phosphoric acid was applied, while plot 70, double superphosphate, showed but five per cent. lodged. On five of the remaining six plots the oats were lodged over the whole area. Three of these plot, 58, fine ground bone, 60, slag meal, and 62, floats received phosphates untreated with acid, and generally considered rather insoluble and slow in action; while plots 54, dissolved bone, and 56, dissolved phosphate rock, received phosphates in a soluble form. Plot 52 also received a soluble phosphate, but the oats lodged only upon half the area of the plot.

If we now turn to the limed series of plots we find that the oats upon all of them lodged, to a greater or less extent. The plot which was without phosphoric acid—67—showed the oats lodged on half its area, and the same was true of the alumina phosphate plots, 63 and 65, while on plot 69, where double superphosphate was used, 80 per cent., and on plot 51, to which dissolved boneblack was applied, 90 per cent., of the crop lodged; the other five, as in the case of the unlimed series, showed the oats lodged over the whole area. The extent of the lodging on the various plots was due to the difference in growth at the time of lodging, there being every prospect of a greater crop in the case of those which lodged than in the case of those which remained standing, or only partially lodged. Of course after that time the growth of those standing went on normally until the time of ripening, while in the case of those lodged, growth was seriously checked, and the weight of straw and grain was doubtless considerably lessened. The weights of the crop do not, therefore, give a reliable basis for judging of the comparative value of the phosphates.

The oats were cut with a scythe, August 7, on all the plots, as it was impossible in their lodged condition to cut them close to the ground with a machine. The weights of the crop on the plots to which lime was applied are compared with the crop from plot

67, using the weights of crop on that plot as 1, and recording in the table as + any excess and as — any deficiency in the various plots. It will be noticed that in three instances, one of grain and two of straw, the yield where phosphate was applied was *less* in the limed series than on plot 67 which received no phosphoric acid. On plot 65, where ignited alumina phosphate was applied, both grain and straw fell below the yield upon plot 67, and this is the more surprising because of the fact that, through accident, the previous year this plot received an additional application of 198 lbs. per acre of the phosphate. In the case of the raw alumina phosphate plot, 63, the yield of grain was greater than plot 67, but the yield of straw was a little less. The raw phosphate is a cheaper article than the ignited. The process of firing is supposed to increase the availability of the phosphoric acid, and it commands a higher price in the market. In the case of the unlimed series the addition of the phosphoric acid increased the yield both of grain and straw in every case.

THE INFLUENCE OF LIMING ON THE OAT CROP.

It will be borne in mind that only one ton of air-slacked lime per acre was applied to the limed series of plots, and that application was made in the spring of 1894. No lime has since been used. The influence of this application is most apparent by comparing the crop produced by the unlimed-no-phosphoric-acid plot, 68, with its opposite in the limed series, plot 67.

No. of Plot.	Yield of Oats per acre.	
	Grain.	Straw.
67. Limed	465 lbs.	4,365 lbs.
68. Unlimed	345 "	2,855 "
Excess of crop on limed plot	120 "	1,510 "

Comparing the total yield of all the plots in the limed with that of the unlimed series, we find the following:

	Grain.	Straw.
Limed Series, total yield	796.50 lbs.	5,437.50 lbs.
Unlimed " " "	776.25 "	4,624.00 "
Increase due to liming	20.25 "	813.50 "

In the case of the plots to which phosphoric acid was applied, four of them gave an excess of both grain and straw on the limed over the unlimed plots. The average excess of grain was 96.9 lbs., and of straw 1,263.1 lbs. In four instances there was a larger yield of grain on the unlimed plots, the average being 82.5 lbs. per acre, and in three cases there was a larger yield of straw on the unlimed plots, giving an average excess of 1,061.6 lbs. This excess of yield on the unlimed plots, as has been before stated, was undoubtedly due to the fact that a far larger percentage of the area of the limed plots lodged than in the case of the unlimed series. Taking the area of the ten plots in each series as a whole, 82 per cent. was lodged in the case of the limed series, while only 55.5 per cent. was lodged in the unlimed series.

SEEDING TO GRASS.

On August 17 the plots were plowed in lands, by laying a back furrow from north to south, through the middle of each pair of plots, and afterward worked with a smoothing harrow to fine the surface preparatory to seeding them to grass for a period of three years. In order to pursue the most rational course in the application of the fertilizers, it was decided to apply a full ration of the *insoluble* phosphates to the respective pairs of plots before seeding. It could then be well worked into the soil, and every opportunity given for obtaining as much effect as possible from these insoluble forms during the three years of grass cropping. In the case of the *soluble* phosphates it would manifestly be unfair to apply the full ration at the time of seeding, especially in the autumn, as there would be no immediate demand for use in plant growth, and the heavy rains would doubtless leach some of the phosphoric acid beyond the reach of grass roots. As all the plots were well fertilized in the spring for the oat crop, it was decided to be more in accord with sound practice to divide the full ration of soluble phosphates into three portions, and apply one each spring as a top-dressing. In that way at the end of three years each pair of plots will have received a full ration of phosphoric acid, excepting, of course, the check plots, 67 and 68, and the *insoluble* phosphates will have been given every opportunity to become available, and the soluble phosphates guarded against loss. One-third of a full ration of nitrate of soda and of muriate of potash is also to be applied each spring, as a top dressing, to all plots alike. Following this plan the only fertilizer applied at time of seeding was the fine ground bone upon plots 57 and 58, slag meal upon plots 59 and 60, floats upon plots 61 and 62, raw alumina phosphate upon plots 63 and 64, and ignited alumina phosphate upon plots 65 and 66. These are all marked in the following table by a dagger; the soluble forms applied in the spring are indicated by a star.

Table of analyses of materials used to supply phosphoric acid, applied autumn of 1895, and spring of 1896.

MATERIALS USED TO SUPPLY PHOSPHORIC ACID.	Cost per ton delivered at Kingston.	Lbs. per plot.[3]	Lbs. applied per acre.	ANALYSES.				
				Phosphoric acid.				
				Per cent. soluble.	Per cent. reverted.	Per cent. insoluble.	Total percentage.	Per cent. nitrogen.
Dissolved boneblack......	$18.00	*26.66	200	13.43	2.12	.35	15.90	....
Dissolved bone.	24.00	*20.00	150	2.70	12.22	4.91	19.83	3.11
Dissolved phosphate rock.	14.00	*34.25	257	11.80	1.02	1.19	14 01	....
Fine ground bone.........	30.00	†58.50	439	.06	20.76	6.29	27.11	2.05
Slag meal.........	20.00	†88.00	660	.00	8.09	9.91	18.00	....
Floats	14.00	†125 50	941	.00	1.70	25.75	27.45	....
Raw alumina phosphate..	25.00	†70.50	529	......	......	.....	35 43	....
Ignited alumina phosphate[4]	40.00	†44.00	330	......	......	......	....	....
No phosphoric acid.......	.....	....	....	......	......	......	....	....
Double superphosphate...	44 00	*10.90	81.8	41.58	6.40	1.23	49.21	...

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* The soluble forms of phosphoric acid were applied as top-dressing, May 15, 1896.

† The insoluble forms of phosphoric acid were applied at time of seeding, Sept. 19, 1895.

[3] Each plot received an application of nitrate of soda at the rate of 183.66 lbs. per acre, and of muriate of potash at the rate of 80 lbs. per acre, as top-dressing, May 15, 1896.

[4] By some oversight, sample was not secured for analysis.

The seeding was done September 19, using a wheelbarrow seeder for the even distribution of the grass seed. The amount for each plot was carefully weighed out, at the following rate per acre:

Timothy (*Phleum pratense*, L.)........	16.87 lbs. (12 quarts).
Red top (*Agrostis vulgaris*, L.)...............	6.00 lbs. cleaned seed.
Red clover (*Trifolium pratense*, L.)...	12.00 lbs.

The ground was very dry, and sowing the clover seed so late in the season was thought to be of doubtful utility, but it was included in the seeding as an experiment. The plots were thoroughly rolled after seeding. Owing to the dry condition of the ground the seed germinated slowly, and, on the limed series, succeeded in getting fairly well established before winter. On the unlimed series, plots 58, 60 and 62, fine ground bone, slag meal and floats, showed the best catch of grass, but these plots were not so good in appearance as their opposites in the limed series. The clover seed made little growth, with no prospect of surviving the winter.

On April 29, 1896, the plots were carefully examined, and, as almost no living clover plants were discovered, medium red clover seed, at the rate of 12 lbs. per acre, was sown over all the plots, and they were then rolled.

On May 15, the plots were top-dressed; one-third of a full ration of phosphoric acid was applied as follows: dissolved boneblack upon plots 51 and 52; dissolved bone upon plots 53 and 54; dissolved phosphate rock upon plots 55 and 56, and double superphosphate upon plots 69 and 70. The term "full ration" is based upon an application of 600 lbs. per acre of dissolved boneblack, and as many pounds of the other forms of phosphate as the cost of that would purchase. A drop of $4.00 per ton in the price of dissolved boneblack, in the spring quotation of 1896, introduced into the experiment a disturbing element, but since the insoluble phosphates had been applied as a full ration, on the basis of 600 lbs. of dissolved bone, it was deemed best to apply, as top-dressing, one-third of the weights determined at that time, although the cost was a little lower. The slight difference in cost was a definite item, and would not interfere with the experiment to such an extent as would the increasing of the weights of the soluble phosphates, as compared with the insoluble forms.

The top-dressing included the application of nitrate of soda, at the rate of 133.66 lbs. per acre, and muriate of potash, at the rate of 80 lbs. per acre, to all the plots. The following notes were taken regarding the appearance of the seeding on the various plots:

MATERIALS USED TO SUPPLY PHOSPHORIC ACID.	LIMED.		UNLIMED.	
	No. of Plot.	Comments.	No. of Plot.	Comments.
Dissolved boneblack.	51	Seeding good, color good.	52	Seeding poor, color pale.
Dissolved bone......	53	Seeding fair, color good.	54	Seeding very poor, color pale.
Dissolved phosphate rock..............	55	Seeding fair, color good.	56	Seeding very poor, color pale.
Fine ground bone...	57	Seeding very good, color good.	58	Seeding good, color rather pale.
Slag meal	59	Seeding fair, color good.	60	Seeding good, color rather pale.
Floats	61	Seeding fair, color good.	62	Seeding fair, color pale.
Raw alumina phosphate.............	63	Seeding poor, color good.	64	Seeding very poor, color pale.
Ignited alumina phosphate........	65	Seeding poor, color good.	66	Seeding very poor, color pale.
No phosphoric acid.	67	Seeding poor, color good.	68	Seeding a failure.
Double superphosphate.	69	Seeding fair.	70	Seeding a failure.

The "catch" of grass seed, and the color of the spring growth, was far better on the limed than on the unlimed plots. Some weeds appeared on the plots, and from May 26th to 28th they were carefully removed by hand. On June 15th, and again on June 22d, the larger ones were pulled, but many weeds were growing on the plots in the unlimed series, especially on 64, 66, 68 and 70. On June 30th the grass was cut for hay, and on July 1st it was piled in heaps, in regular order, and photographed. The accompanying illustrations show the relative size of the heaps cut from the various plots. On the unlimed plots, 64, 66, 68 and 70, no hay was harvested, the ground being covered with a scanty growth of noxious weeds. The following table gives the weights of field cured hay per plot and per acre, and the gain or loss due to the use of the various forms of phosphates in both the limed and unlimed series, and the increase due to liming.

Table showing the results of various kinds of Phosphates used, in quantities having an equal money value, both with and without lime, upon Grass in 1896.

MATERIALS USED TO SUPPLY PHOSPHORIC ACID.	Lbs. applied per acre[2]	LIMED.[1]				UNLIMED.				Lbs. gain per acre due to liming.
		Number of plot.	Lbs. of hay per plot.	Lbs. of hay per acre.	Lbs. per acre gain (+) or loss (—) compared with plot 67.	Number of plot.	Lbs. of hay per plot.	Lbs. of hay per acre.	Lbs. per acre gain (+) or loss (—) compared with plot 68.	
*Dissolved boneblack……	200	51	380	3800	+3000	52	80	800	+ 800	3000
*Dissolved bone…………	150	53	210	2100	+1300	54	25	250	+ 250	1850
*Dissolved phosphate rock..	257	55	353	3530	+2730	56	80	800	+ 800	2730
†Fine ground bone………	439	57	545	5450	+4650	58	445	4450	+4450	1000
†Slag meal………… …..	660	59	500	5000	+4200	60	400	4000	+4000	1000
†Floats…………………	941	61	335	3350	+2550	62	265	2650	+2650	700
†Raw alumina phosphate…	529	63	70	700	— 100	64	00	00	00	700
†Ignited alumina phosphate.	330	65	240	2400	+1600	66	00	00	00	2400
No phosphoric acid……..	…	67	80	800	…	68	00	00	…	800
*Double superphosphate….	81.8	69	175	1750	+ 950	70	00	00	00	1750

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[1] One ton of air-slacked lime per acre was applied in 1894

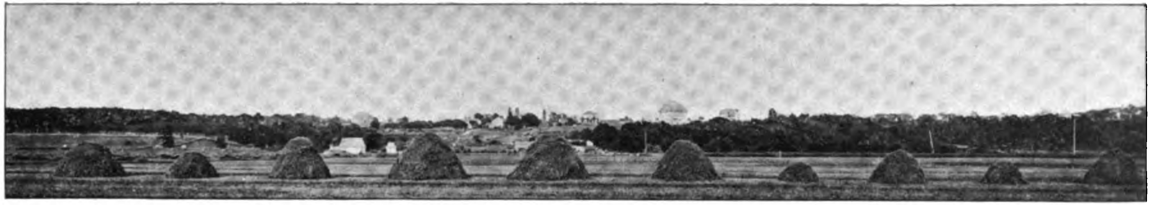
[2] Each plot received an application of nitrate of soda, at the rate of 138.66 lbs. per acre, and of muriate of potash, at the rate of 80 lbs. per acre, as top-dressing, May 15th, 1896.

* Applied in the spring of 1896, as top-dressing.

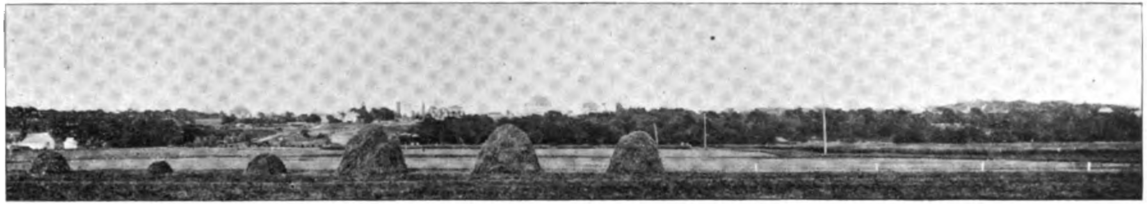
† Applied in the fall of 1895, at time of seeding.

Looking first at the weights of hay from the unlimed plots one notes the remarkable yield on plots 58, 60 and 62, where fine ground bone, slag meal and floats, were respectively used. The yield upon the two former considerably exceeded the latter. This was doubtless due, in part at least, to the neutralizing effect of the lime contained in them. The total failure on plots 64, 66, 68 and 70, and the very small yields on plots 52, 54 and 56, are probably more largely due to the severe conditions imposed upon the young grass plants, by reason of the acid reaction of the soil, than to the actual influence of the elements of plant food in the fertilizers applied.

Turning to the limed plots we find, in every instance, a greater yield than from the corresponding unlimed plots. What was true in the unlimed series is true here, viz.: the fine ground bone, plot 57, and slag meal, plot 59, gave respectively the best two crops, and in each case just half a ton more per acre than the corresponding unlimed plots. Floats, plot 61, although giving a crop 700 pounds per acre heavier than the unlimed plot, 62, was exceeded in yield by the dissolved boneblack plot, 51, and also plot 55, on which dissolved phosphate rock was used; the increase in the latter case, however, was slight, being only 180 lbs. per acre. The crop produced by dissolved bone was considerably less than that produced by dissolved boneblack or dissolved phosphate rock. There appears to be but little difference in the effect of the last two named. In the unlimed series the yields were identical, and in the limed series only a difference of 270 lbs. per acre, but the difference between the two series due to liming was 1½ tons per acre in the case of one, and nearly as much in the other. As to the other form of soluble phosphate, double superphosphate, there was no crop on the unlimed plot, 70, but on the limed plot, 69, a crop of 1,750 pounds per acre, or 350 pounds less than that produced by dissolved bone, and not half the crop produced by the other two forms of soluble phosphates. The alumina phosphates, both raw and ignited, were a failure on the unlimed plots, and the raw alumina phosphate in the limed series produced only



Yield of hay. Phosphate Experiment. Plots Limed.



Yield of hay. Phosphate Experiment. Plots Unlimed.

UNIV. OF MICH.

700 pounds of hay per acre, or 100 pounds less than was produced on the check plot, 67, without any application of phosphoric acid. The ignited alumina phosphate, plot 65, gave a far better crop, 2,400 pounds, or just 3 times that produced on the check plot. That yield is, however, less than half as much as was produced by the fine ground bone on plot 57, or the slag meal on plot 59. The last column of the table gives the increase of crop on the various plots, which may fairly be attributed to the effect of the application of 1 ton of air-slacked lime per acre in 1894. It will be noticed that the increase varied from 700 lbs. to 3,000 lbs. of hay per acre, and that the increase was not as great in the case of the phosphates which gave the greatest yields as in the case of the soluble phosphates. If we find the total crop produced by all the plots in each series we get composite results from the use of all the forms of phosphoric acid, with and without lime, in which the influence of the lime is plainly shown. The total of the crops from the 10 one-tenth acre plots of each series gives a yield per acre. The limed plots produced 2,888 lbs. of hay, while the unlimed plots produced only 1,295 lbs., a difference of 1,593 lbs. per acre in favor of the liming, in the crop of a single season.

After harvesting the hay some weeds started, and July 25th the plots were cut over with a mowing machine to clip all weeds, whatever was cut being allowed to fall and lie on the ground.

August 25th the plots were again cut over, and as the grass on some plots had started considerably, the cutter bar was set well up so as to clip only the tops of the clover and weeds, which, as before, were allowed to fall and lie on the ground. The material cut on the unlimed series was wholly weeds, and on the limed series about one-half clover.

SUMMARY.

The plan of this experiment, commenced in 1894, is to apply the same money value of various materials used to supply phosphoric acid, together with a suitable and like quantity of nitrate of soda and muriate of potash to two series, of ten plots each (including one check plot without phosphoric acid), one series limed at the rate of 1 ton per acre at the beginning of the experiment, and the other series unlimed. The reader is referred to the plan of permanent experimental plots, where this experiment includes plots 51 to 70, the odd numbers being included in the limed series on the north side, and the even numbers in the unlimed series on the south side.

In the fall of 1895, when the plots were seeded to grass, a full ration of the *insoluble* phosphates, fine ground bone, slag meal, floats, raw alumina phosphate, and ignited alumina phosphate was applied. With the *soluble* phosphates, dissolved boneblack, dissolved bone, dissolved phosphate rock,[1] and double superphosphate, none were used at time of seeding, but one-third of a full ration is applied, each of three successive springtimes, as a top-dressing. A one-third ration of nitrate of soda and muriate of potash is applied to all the plots.

The oat crop of 1895 showed a better color, and more rapid growth, on the limed series, and, during a severe storm, 82 per cent. of the oats in that series, as compared with 55.5 per cent. in the unlimed series, became lodged, which fact necessarily interfered with normal growth and value of results.

Clover seed sown with grass seed, September 19th, proved a failure, and more was sown April 29th, which has produced a fair admixture of clover in the hay, especially on the limed series of plots.

The grass, in the spring of 1896, showed a much deeper green color throughout the limed series, and in the unlimed plots which have received fine ground bone, slag meal and floats presented the best appearance. The phosphates above named gave the best "catch" in both series, while dissolved boneblack, dissolved bone and dissolved phosphate rock were next in rank, giving a fair to good "catch" in connection with lime, but a very poor one without it. Double super-phospate gave a fair "catch" with lime, and without it a failure. The raw and ignited alumina phosphates, and the plot with no phosphoric acid, gave the poorest "catch" in the limed series, and without lime a practical failure.

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[1] Often called acid phosphate.

It is manifestly unfair to judge the efficiency of the various phosphates at this time, because only three years have elapsed since the experiment was begun, but especially because the *soluble* phosphates will not be upon an equal footing with the *insoluble*, until two more annual top-dressings have been applied. Judging from the crops produced thus far, they appear to stand in the following order: fine ground bone, slag meal, floats, dissolved boneblack, dissolved phosphate rock (three last named about equal), dissolved bone, double superphosphate, ignited alumina phosphate and raw alumina phosphate, the latter failing to produce as good a crop as the check plot, without phosphoric acid.

The application of one ton of air-slacked lime per acre at the beginning of the experiment, in connection with the phosphates, has produced a marked beneficial effect, as seen in the general color, growth and appearance of the crops. The yields have been greater from the limed series than from the unlimed with all the crops grown since the installation of the experiment, the increase due to liming being as follows: corn crop of 1894 (9 plots), 669.3 lbs. stover, 460.9 lbs. hard corn, and 43.8 lbs. soft corn; oat crop of 1895 (10 plots), 20.25 lbs. of grain and 813.5 lbs. of straw; hay crop of 1896 (10 plots), 1,593 lbs.

FURTHER TESTS OF NORTHERN AND HOME GROWN SEED POTATOES.

CHAS. O. FLAGG AND G. M. TUCKER.

In bulletin No. 36 of this Station an account is given of the results obtained by planting seed potatoes of fourteen varieties, grown in Aroostook Co., Maine, in 1894, and the planting in 1895 of a fresh supply of northern grown seed, in comparison with the same kind and weight of seed tubers grown on the Station grounds in the previous year's experiment. In 1896 a fresh supply of northern grown seed tubers of the same varieties, in so far as it was possible to obtain them, was purchased, and planted for comparison with seed tubers grown on the Station farm from northern seed for one and two successive years. The field selected for this trial was the west end of "Field A," east of the plain barn, and 80 by 208 feet in area. It had produced potatoes the previous year, and was of similar character and quality with that used in the experiment in 1895. The land was plowed with a sulky swivel plow, April 25th, and well harrowed. The fertilizer used was made up as follows: nitrate of soda, 105 lbs.; tankage, 750 lbs.; dissolved phosphate rock, 540 lbs.; fine ground bone, 120 lbs.; muriate of potash, 300 lbs.; making a total of 1,815 lbs. per acre. The amount of fertilizer required for the area planted was calculated, and three-fourths of the quantity was applied broadcast, as evenly as possible, on April 27th, and well worked into the soil. The plot was planted on May 7th and 8th. The ground was marked out by opening furrows in an easterly and westerly direction, thirty inches apart. The fertilizer remaining—one-fourth of the total application—was evenly distributed along the drills and mixed with the soil. The sets were planted twelve inches apart in the drill, and in the case of each variety ten pounds of seed tubers were cut into 160 pieces (an average of one ounce each) and planted in two rows, designated in the tables as "north row" and "south row." This method of seeding may appear to some planters as less uniform than the cutting of the seed tubers to a uniform number of eyes, but Arthur has shown[1] "that the number of eyes per piece is immaterial, but that the weight of the piece is a very important factor," therefore this method of seeding was adopted as tending towards greater uniformity. The varieties were planted consecutively and then repeated, so that the influence of any slight inequality in the condition of the land or fertilization might be nullified so far as possible. On May 27th Breed's weeder was used on the plot, and on June 1st a hand cultivator was run between the rows. They were cultivated and hoed, at intervals, sufficiently often to keep the surface of the ground mellow and free from weeds. On June 26th the first application of Paris green was made with the Excelsior powder duster; other applications were made on July 4th and 10th. Potato blight appearing in the vicinity, Bordeaux mixture was applied on the following dates: July 15th, 17th, 21st, 24th and 28th. The tops of the early varieties of potatoes began to die soon after the last spraying, and on August 7th an estimate was made of the degree of maturity, on the scale of 100 for tops entirely dead. The following table (I) gives the figures obtained:

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[1] Purdue University Agrl. Expt. Sta. Bul. No. 42.

TABLE I.

Table showing the Degree of Maturity of Potato Crop produced from Maine grown and Rhode Island grown Seed Tubers, 1895 and 1896.

NAME OF VARIETY.	Degree of Maturity, given in per cent., estimated from condition of vines, on the dates named.										
	North Rows. August 7, 1896.			South Rows. August 7, 1896.			Average of North and South Rows.			Aug. 1, 1895.	
	1st[1] Year.	2d[2] Year.	3d[3] Year.	1st Year.	2d Year.	3d Year.	1st Year.	2d Year.	3d Year.	1st Year.	2d Year.
Early Norther.....	50	40	5	50	60	10	50.0	50.0	7.5	50	25
Thorburn..........	30	40	90	30	30	60	30.0	35.0	75.0	00	25
King of the Early..	50	60	20	40	70	30	45.0	65.0	25.0	50	25
Early Maine........	70	60	40	40	40	30	55.0	50.0	35.0	50	25
White Star.........	5	5	0	5	0	5	5.0	2.5	2.5	00	25
Houlton Hebron....	5	30	40	0	5	10	2.5	17.5	25.0	25	25
Burbank....	5	10	5	20	40	10	12.5	25.0	7.5	25	15

September 4th the potatoes were dug, carefully counted, assorted and weighed. All tubers three ounces or more in weight were classed as large or merchantable tubers, while those below that weight were called small. Table II gives the weights of crop produced by the three classes of seed tubers in duplicate rows, and table III the number of tubers produced in each instance. In table IV the two preceding tables are summarized, and an average of the weights and numbers produced by each class of seed tubers is given, and at the bottom of the table is given the average of all the varieties; it is here that we are to look for the influence of the seed tubers upon the crop. Any difference in vitality or power of reproduction or tendency, on the part of the home grown seed tubers to produce small potatoes, should be evident in the average of all the varieties obtained from the average yield of the two rows. The average at the foot of the table is given in pounds or in numbers for one row, and as each row occupied a space of 80 x 2½ feet, the ground occupied was equivalent to a 217.8 part of an acre. If now we reduce the average total weight of all the varieties into yields per acre, we get, as the yield of the first year seed, 158.52 bushels; for the second year seed, 186.94 bushels, and for the third year seed, 175.54 bushels. That is, the first year or northern grown seed produced 28.42 bushels *less* per acre than the crop produced by seed grown in this State from northern seed tubers. The third year seed exceeded the yield of the first year seed by 17.02 bushels. Let us now turn to the yield of large tubers. In the experiment reported in bulletin 36, all tubers, two ounces or more in weight, were classed as merchantable, but in the work reported here the limit was fixed at three ounces, which doubtless decreased, to a considerable extent, the proportion of merchantable tubers, but tubers between two and three ounces in weight, while perhaps salable, injure the appearance and market value of a crop, when they form too large a proportion of it; therefore the three ounce limit was thought to be preferable for the present purpose. We find here that the first year seed, while giving the smallest total yield, gave a little the largest yield of large tubers. Reduced to yields per acre the figures would be as follows: first year, 70.20 bushels; second year, 68.71 bushels; third year, 67.99 bushels. These figures, when compared with the average yields, show that the increase in the crop was mainly small potatoes, and not a merchantable product. This is forcibly illustrated in the columns of the table, giving the numbers of tubers produced, perhaps more readily seen when arranged in the following order:

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[1] First year indicates crop produced from northern grown seed.

[2] Second year indicates crop produced from seed tubers grown in Rhode Island from northern seed.

[3] Third year indicates crop produced from seed tubers grown two successive years in Rode Island from northern seed.

	1st year.	2nd year.	3rd year.
Average total number....................	316.0	427 8	396.1
" number, large..................	69.8	73.1	74.1
" " small................	246.2	326.1	310.1

The crop from the second and third year seed, while giving a very small excess in number of large tubers over the first year seed, greatly exceeded the first year in number of small potatoes produced. This conclusion is still further strengthened by the data in table V. The average weight of the tubers produced from the three kinds of seed is given for each variety in the first nine columns, and at the bottom the average for all the varieties. We will place the final averages in columns of first, second and third year, and the difference in the figures will perhaps be more evident:

Average of all varieties.	1st year.	2nd year.	3rd year.
Average weight of tubers, total number...	0.135	0.120	0.120
Average weight of large[1] tubers...........	0.270	0.250	0.250
Average weight of small tubers....	0.100	0.090	0.100
Per cent. of large tubers by number, 1896..	22.17	20.25	19.45
Per cent. of large tubers by weight, 1896..	43.05	35.84	38.41
Per cent. of large[2] tubers by weight, 1895.	72.77	69.45	.....

It is evident that the first year or northern grown seed has equalled or exceeded the home grown seed in every point enumerated above.

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[1] In 1896 all tubers weighing 3 ounces or more were classed as large.

[2] In 1895 all tubers weighing 2 ounces or more were classed as large.

TABLE II.

Table showing the Weights of Tubers produced from Maine grown and Rhode Island grown Seed Tubers in 1896.

NAME OF VARIETY.	WEIGHT OF TOTAL YIELD.						WEIGHT OF LARGE[4] TUBERS.						WEIGHT OF SMALL TUBERS.					
	1st Year.[1]		2d Year.[2]		3d Year.[3]		1st Year.		2d Year.		3d Year.		1st Year.		2d Year.		3d Year.	
	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.
Early Norther	62.25	44.75	52.00	41.25	54.25	33.50	23.25	15.00	13.25	7.25	24.25	7.75	39.00	29.75	38.75	34.00	30.00	25.75
Thorburn	52.50	43.00	69.25	46.50	58.25	42.50	31.50	25.00	38.00	16.25	17.50	7.75	21.00	18.00	31.25	30.25	40.75	34.75
King of the Early	44.00	40.75	51.00	42.75	22.00	26.00	15.50	14.25	15.50	9.00	9.25	10.00	28.50	26.50	35.50	33.75	12.75	16.00
Early Maine	29.00	32.50	45.25	48.00	50.50	38.50	7.75	9.75	12.00	13.25	18.50	12.75	21.25	22.75	32.75	34.75	32.00	25.75
White Star	65.25	57.25	60.50	51.50	67.75	50.75	38.50	31.00	28.50	26.50	33.25	25.75	26.75	26.25	32.00	25.00	34.50	25.00
Houlton Hebron	33.50	32.75	59.50	58.25	66.75	64.75	17.50	17.25	27.00	28.00	28.75	26.25	16.00	15.50	32.50	24.75	38.50	38.50
Burbank	41.00	29.00	61.00	39.25	62.00	39.50	15.50	9.00	20.25	10.25	29.25	11.25	25.50	20.00	40.75	29.00	32.75	28.50

[1] First year indicates crop produced from northern grown seed.

[2] Second year indicates crop produced from seed tubers grown in Rhode Island from northern seed.

[3] Third year indicates crop produced from seed tubers grown two successive years in Rhode Island from northern seed.

[4] All tubers weighing three ounces or more were classed as large.

TABLE III.

Table showing the Numbers of Tubers produced from Maine grown and Rhode Island grown Seed Tubers in 1896.

NAME OF VARIETY.	TOTAL NUMBER OF TUBERS.						NUMBER OF LARGE[4] TUBERS.						NUMBER OF SMALL TUBERS.					
	1st Year.[1]		2d Year.[2]		3d Year.[3]		1st Year.		2d Year.		3d Year.		1st Year.		2d Year.		3d Year.	
	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.	North Row.	South Row.
Early Norther	430	348	412	485	382	327	100	57	52	30	88	31	330	291	360	455	294	296
Thorburn	330	273	465	396	535	449	102	86	137	63	68	32	228	187	328	335	467	417
King of the Early	312	360	462	498	151	226	62	52	66	36	31	42	250	308	396	462	120	184
Early Maine	274	283	299	471	420	359	34	36	53	54	75	50	240	247	246	417	345	309
White Star	301	369	421	352	368	338	137	110	107	97	118	92	164	259	314	255	250	246
Houlton Hebron	206	259	443	372	491	468	54	62	101	108	111	94	152	197	342	264	380	374
Burbank	401	278	515	398	455	377	58	27	79	40	117	49	343	251	436	358	338	328

[1] First year indicates crop produced from northern grown seed.

[2] Second year indicates crop produced from seed tubers grown in Rhode Island from northern seed.

[3] Third year indicates crop produced from seed tubers grown two successive years in Rhode Island from northern seed.

[4] All tubers weighing three ounces or more were classed as large.

TABLE IV.

Table showing the Average Yields, in Weights and Number of Tubers, produced from Maine grown and Rhode Island grown Seed Tubers in 1896.

NAME OF VARIETY.	AVERAGE WEIGHT, IN POUNDS, OF TUBERS IN NORTH AND SOUTH ROWS.									AVERAGE NUMBER OF TUBERS IN NORTH AND SOUTH ROWS.								
	Total.			Large.[4]			Small.			Total.			Large.[4]			Small.		
	1st[1] Year.	2d[2] Year.	3d[3] Year.	1st Year.	2d Year.	3d Year.	1st Year.	2d Year.	3d Year.	1st Year.	2d Year.	3d Year.	1st Year.	2d Year.	3d Year.	1st Year.	2d Year.	3d Year.
Early Norther	55.50	46.63	43.88	19.13	10.25	16.00	34.38	36.38	27.88	389.0	448.5	354.5	78.5	41.0	59.5	310.5	407.5	295.0
Thorburn	47.75	57.88	50.38	28.25	27.13	12.63	19.50	30.75	37.75	301.5	430.5	492.0	94.0	100.0	50.0	207.5	330.5	442.0
King of the Early	42.34	46.88	24.00	14.88	12.25	9.63	27.50	34.63	14.38	336.0	480.0	288.5	57.0	51.0	56.5	279.0	429.0	153.0
Early Maine	30.75	46.63	44.50	8.75	12.63	15.63	22.00	33.75	28.88	278.5	385.0	389.5	35.0	53.5	62.5	243.5	331.5	34.0
White Star	61.25	56.00	59.25	34.75	27.50	29.50	26.50	28.50	29.75	335.0	386.5	353.0	123.5	102.0	105.0	211.5	284.5	248.0
Houlton Hebron	33.13	56.38	65.75	17.38	27.50	27.50	15.75	28.63	38.50	232.5	407.5	479.5	58.0	104.5	102.5	174.5	303.0	377.0
Burbank	35.00	50.13	50.75	12.25	15.25	20.25	22.75	34.88	30.63	339.5	456.5	416.0	42.5	59.5	83.0	297.0	397.0	333.0
Average	43.67	51.50	48.36	19.34	18.93	18.73	24.05	32.70	29.68	316.0	427.8	396.1	69.8	73.1	74.1	246.2	326.1	310.1

[1] First year indicates crop produced from northern grown seed.

[2] Second year indicates crop produced from seed tubers grown in Rhode Island from northern seed.

[3] Third year indicates crop produced from seed tubers grown two successive years in Rhode Island from northern seed.

[4] All tubers weighing three ounces or more were classed as large.

TABLE V.

Table showing the Average Weights and Percentages of Yields of Potatoes produced from Maine grown and Rhode Island grown Seed Tubers in 1895 and 1896.

NAME OF VARIETY.	AVERAGE WEIGHT OF TUBERS.									PER CENT. OF LARGE[4] TUBERS, BY NUMBER, 1896.			PER CENT. OF LARGE[4] TUBERS, BY WEIGHT, 1896.			PER CENT. OF LARGE[5] TUBERS, BY WEIGHT, 1895.	
	Total.			Large.[4]			Small.										
	1st[1] Year.	2d[2] Year.	3d[3] Year.	1st Year.	2d Year.	3d Year.	1st Year.	2d Year.	3d Year.	1st Year.	2d Year.	3d Year.	1st Year.	2d Year.	3d Year.	1st Year.	2d Year.
Early Norther	0.14	0.10	0.12	0.24	0.25	0.27	0.11	0.09	0.09	20.18	9.14	19.60	34.47	21.98	36.46	71.37	71.12
Thorburn	0.16	0.12	0.10	0.30	0.27	0.25	0.09	0.09	0.12	31.17	43.05	10.16	59.16	46.88	25.69	82.55	68.19
King of the Early	0.12	0.10	0.09	0.26	0.24	0.17	0.10	0.08	0.09	16.99	10.63	19.59	35.11	26.11	40.12	73.51	82.39
Early Maine	0.11	0.12	0.11	0.25	0.24	0.25	0.09	0.10	0.09	12.56	13.89	16.04	28.25	27.62	35.12	66.85	66.85
White Star	0.18	0.14	0.16	0.28	0.26	0.28	0.13	0.10	0.12	36.86	26.39	29.46	56.78	49.11	49.79	71.02	66.01
Houlton Hebron	0.14	0.14	0.14	0.30	0.26	0.27	0.09	0.09	0.10	24.94	25.64	21.37	52.46	48.77	41.88	72.49	70.78
Burbank	0.10	0.11	0.12	0.28	0.25	0.24	0.08	0.09	0.09	12.52	13.08	19.94	35.00	30.42	39.90	71.57	61.33
Average	0.135	0.12	0.12	0.27	0.25	0.25	0.10	0.09	0.10	22.17	20.25	19.45	43.05	35.84	38.41	72.77	69.45

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[1] First year indicates crop produced from northern grown seed.

[2] Second year indicates crop produced from seed tubers grown in Rhode Island from northern seed.

[3] Third year indicates crop produced from seed tubers grown two successive years in Rhode Island from northern seed.

[4] All tubers weighing three ounces or more were classed as large.

[5] In 1895 all tubers weighing two ounces or more were classed as large.

SUMMARY.

Northern grown seed tubers, first year, produced 28.42 bushels *less* per acre in total crop of large and small potatoes than was produced by home grown seed, second year, and 17.02 bushels *less* than home grown seed, third year, but the excess of yield in the crop from the home grown seed consisted of tubers *less than* three ounces in weight, classed as "small."

While the northern grown or first year seed produced a crop 28.42 bushels per acre *less* than the home grown second year seed, the yield of tubers, three ounces or more in weight, was 1.29 bushels *greater* than the home grown second year seed, and 2.21 bushels *greater* than was obtained from the home grown third year seed.

The average weight of the large tubers, produced by the northern grown or first year seed, was 0.27 pounds or 4.32 ounces, as compared with 0.25 pounds or 4. ounces in the crops from the home grown seed, both second and third years.

The per cent. of large tubers, by both numbers and weights, was greater in the case of the northern grown seed.

The per cent. of large tubers, by weight, was greater in the case of the northern grown seed, in the experiment of 1895.

POULTRY DIVISION.

CHAS. O. FLAGG.

The work of this division was in charge of Mr. Samuel Cushman until July 1st, since which time it has been a part of the duty of the Director and Agriculturist. The same poultryman, Mr. James Lynch, has faithfully attended to the manifold duties always connected with the care of poultry, and his interest and good judgment have added measurably to the success of the work.

ANALYSES OF POULTRY FOODS.

A number of feeding stuffs found on the market, and used to a greater or less extent as food for poultry, have been analyzed by the Chemical Division some time since, and the results not heretofore published. The list of foods, with laboratory numbers and analyses, is given below:

No. 42. Common Navy Bread,
No. 43. Austin's Dry Bread,
No. 44. Brooklyn Azzotine,
No. 45. Boiled Blood and Bone,
No. 46. Bowker's Animal Meal,
No. 47. Smith's Beef Scraps,
No. 48. Avery's Beef Scraps,
No. 49. Darling's Ground Scraps,
No. 72. Germ Feed.

ANALYSES OF FEEDING STUFFS FROM POULTRY DIVISION.

Mineral Analyses and Amount of Nitrogen.

	42	43	44	45	46	47	48	49	72
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water	9.17	10.33	10.58	7.35	5.03	7.03	6.89	8.72	9.45
Lime (calcium oxid)	.12	.53	4.25	26.84	16.20	6.36	3.87	8.18	19.14
Magnesia (magnesium oxid)	.17	.14	.16	.69	.31	.25	.18	.27	.46
Potash (potassium oxid)	.25	.35	.72	.38	.33	.78	.79	.67	.38
Phosphoric acid	.63	.98	4.02	21.81	13.38	4.94	4.96	6.88	15.30
Nitrogen	2.62	2.70	9.28	4.69	5.43	5.87	8.85	8.34	7.31
Insoluble matter	.02	.03	.67	.84	.76	1.41	.33	2.18	.36

Fodder Analyses (Per cent. of water same as above).

	42	43	44	45	46	47	48	49	72
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Crude ash	1.41	4.82	15.07	52.90	33.89	18.23	11.72	21.70	39.21
Crude fat (ether extract)	1.34	4.33	11.13	2.07	19.50	15.43	24.50	13.83	2.00
Crude protein (Nitrogen X 6.25)	16.38	16.88	58.00	29.31	33.94	36.69	55.31	52.13	45.69
Crude cellulose (fibre)	1.06	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-nitrogenous extract matter	70.64	63.12	5.22	8.37	8.14	22.62	1.58	3.62	3.65

CROSS-BREEDING OF GEESE.

The breeding of pure and cross-bred geese, numbering in all 21 pens, has been the chief work of the year. As ganders mate with only one to three or four geese (wild ganders mate with but one goose), and are strongly attached not only to their mates, but to that particular portion of the farm or poultry yard which is their home, any disturbance of "family ties" or change of locality just prior to or during the breeding season is highly detrimental, and often fatal, to successful results. The absolute necessity for confining breeding geese in yards, where so many are kept for experimental purposes, is obvious, although goose raisers will all agree that the very best results are generally obtained where geese have freedom of range, or at least are not sensible of confinement. The experimental work with breeding geese in previous years has been seriously interfered with by the difficulty of getting all the pens mated and confined in permanent quarters sufficiently early in the season, and by disturbance incident to the conduct of quarrying operations in the vicinity. Guided by the experience previously gained, plans were matured toward the close of 1895 for the breeding season of 1896, by Mr. Cushman who was then in charge of the work, and five pens of pure breeds, and sixteen pens mated for cross-breeding, were located in December. The pens were 60 x 60 feet, enclosed by wire poultry fencing, 4 feet high, and each pen afforded an opportunity for the geese to get into water, either in an excavation naturally filled with water, or in a large tub sunk in the ground to a level with the surface and filled with water. It is designed at the close of the goose cross-breeding experiment to put the results into bulletin form, and, therefore, only a few general statements regarding the season's work will be given here.

Goose raisers do not care, as a rule, to have goslings hatched much before grass begins to start in the spring, as they thrive much better when tender grass forms quite a portion of their diet; hence very early laying is not usually desired. In very cold weather the eggs are also quite liable to become chilled, and not hatch as well.

One White China goose laid two eggs in January, and by the last of February several geese had laid, and March 3rd 16 eggs were obtained from 43 geese, although but one was laid on the 2nd and 1 on the 4th. The majority of the eggs were laid in March, April and May. Only a few were laid in June. The following shows the number of eggs produced by the various pure-bred females, excepting those in pen 22, where more than one breed was kept:

GOOSE EGGS LAID IN 1896.

9 Africans	laid	147	eggs,	average	number	16.33	eggs.
11 Embdens	"	202	"	"	"	18.36	"
8 Toulouse	"	224	"	"	"	28.12	"
7 Brown Chinas	"	217	"	"	"	31.00	"
5 White Chinas	"	155	"	"	"	31.00	"

One White China goose made a record of 47 eggs, laid during the season, but none of her eggs proved fertile. The eggs were hatched under hens, each large hen covering 5 eggs. An incubator was used at the beginning of each hatch, and when the eggs were tested the fertile ones were all placed under hens. Each egg was marked with the number of the pen where it was laid, and, so far as possible, eggs from only one pen were placed under one hen, and the goslings were marked by punching the web of the foot as soon as hatched, so that at any time it was an easy matter to determine the parentage of any gosling.

The eggs did not prove as fertile as could be desired, or as is generally the case where geese are kept with comparatively free range, and bred for market purposes. The young goslings three or four weeks old were confined in pens at night, and during the day confined by movable wire fencing—hurdled—on grass or tender fodder crops. This was necessary on account of limited pasturage. Later on green foods were given to them in the pens at night.

On the night of the 22nd of June dogs broke down the gate and wire fencing of one pen, and attacked the goslings. Some were killed on the spot, and others were chased for a quarter of a mile or more across some of our experimental plots,[1] and the entire flock, with barely an exception, killed or seriously maimed. A watch was kept for several nights, but as no disturbance was made, it was discontinued. On the 29th of June, however, some old geese, in the most distant pen, were attacked and killed, and a pen containing a few goslings broken into and some killed. Altogether 54 goslings, 5 geese and 3 ganders were killed outright

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See page 225 and foot note on page 234.

or maimed, so that death resulted. Under the "damage by dogs" law the Station received from the town treasurer a reasonable market value for the birds killed, but the interruption of the experiment was without remedy, and deeply regretted. During the season 221 goslings were reared to maturity. Weights were obtained at 5, 8 and 10 weeks of age, and representatives of the various crosses were photographed. Some of them were fattened and sold as "green geese," and others kept and exhibited at the Rhode Island Poultry Society show, at Westerly, in December. Specimens of the various crosses were shown, both alive and dressed. The first lot of goslings were 97 days old when dressed for market, and the heaviest and best lot was bred from pen 15, in which an Embden gander was mated with African geese. There were 9 goslings from this pen, and the average live weight was 15 pounds, $3\frac{4}{9}$ ounces, and the average dressed weight, ready for market, 13 pounds, $7\frac{5}{9}$ ounces. There were many desirable birds from other pens, but none which made such rapid growth as this cross. The Embden-Toulouse cross developed into large birds, but not as quickly as the Embden-African cross. It appears to be desirable to use a *white* bird for one parent in making a cross, in order, so far as possible, to grow white, pied or light colored birds for market, because they pick much easier, usually have a whiter flesh, and are handsomer in appearance. These are important points, and affect the price when the bird comes on the market. Entirely dark birds, as Africans, Toulouse or Brown Chinas, have black pin feathers, which make them hard to pick when dressed as green geese. If they are not thoroughly taken out they show on the dressed bird very distinctly, and injure the appearance, while white pin feathers are much less objectionable. The color of the flesh, aside from the effect of the black or white pin feathers is, as a rule, in favor of the white or light colored bird. Toulouse, Brown China and African geese, unless very fat, are generally of a darker appearance when dressed than Embdens or White Chinas.

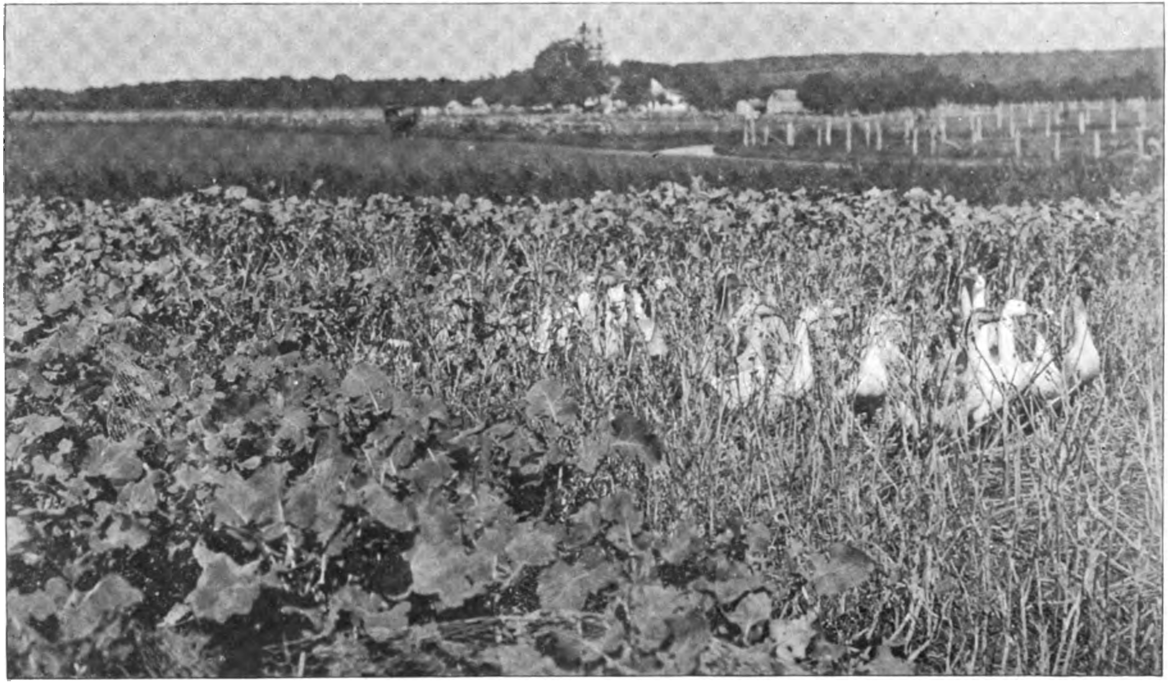
FODDER CROPS FOR GEESE.

Geese will consume a great variety of food, probably a greater variety than any other class of poultry. It a wild state they do not stray far from some body of water, except in their migratory journeys, and then some lake, pond or river is selected as a place to rest from flight and obtain food. Aquatic plants and roots, with worms and insects dug out of the mud in shallow waters, and probably some tender herbage growing along the shores, constitutes the food of the wild goose. It can hardly be said to subsist by *grazing*, as it depends largely upon water for both food and protection. The domestic goose, however, like the sheep, is an epicure respecting tender grasses and juicy fodder plants. After the breeding season is past, the old stock, which only requires to be kept in good store condition until the approach of another breeding season, can be economically kept by confining them to a pasture, where they easily obtain most of their living by grazing. They should have access to water at all times, and a little dry corn occasionally is acceptable. If the supply of grass is scanty, more grain should be fed, or, better, they may be supplied with green foods, cultivated for the purpose, after the manner of growing soiling crops for feeding cattle. By this method people with comparatively small areas of land may grow large flocks of goslings, confining them upon a limited area, and cultivating fodder crops to be cut and fed to them day by day; or they can be confined upon the growing crops by the use of movable fences. When the crop is eaten sufficiently close the fence is moved to a new area, and the other allowed to grow up for a second feeding, or the land plowed and planted to a new crop.

As almost no ground was available for pasturage near the poultry yards, preparations were made early in the spring for growing some fodder crops as green food for the goslings. Oats, both with and without Canada peas, were sown as early as possible, at the rate of about four bushels of oats and one of peas per acre, so as to get a thick stand. When the grain was three or four inches high the goslings were hurdled upon it, using at first wire netting one foot high, held in place by iron rods to confine them. Water and sharp sand, thoroughly wet, was kept continually by them, and they were fed soaked cracked corn, at intervals of two hours, when quite small, and less frequently as they grew older. The oats were always eaten before the peas, and unless the crop was fed very closely the peas would remain untouched. When the oats are young, the goslings should be changed from place to place frequently, so that the roots of the oats will not be killed by too close feeding. A succession of oats can be had by making several sowings at intervals of a week. Green oats are greedily eaten by large goslings or old geese, as long as the stems have not turned yellow and grown fibrous and tough.

The first green food in the spring can be supplied by fall sown rye, but grass seems to be preferred by goslings if obtainable. Soon after rye begins to "joint" or send up seed stalks, it becomes hard and tough, and is not relished. Cabbage, turnips and sweet corn, are excellent soiling crops for geese. Sweet corn, sufficiently advanced to be in the roasting-ear stage, will be almost or quite devoured, when fed at night to geese in pens. Only small pieces of the largest and hardest butts will remain uneaten. Hungarian grass or millet was tried, but it did not appear to be relished at any stage of its growth.

Two very satisfactory plants used were sorghum and Dwarf Essex rape. Two varieties of sorghum, planted June, 13th were Early Orange sugar cane and Early Amber cane. They require a well fertilized, warm soil in this latitude, and the growth at first is rather slow. The seed was sown on mellow, thoroughly prepared ground, in drills eighteen inches apart. On July 27th the sorghum measured about ten inches in height. Later on alternate rows were cut out and fed, and that remaining grew to a height of six or seven feet. The geese were very fond of it at all stages of its growth. A small piece was sown broadcast, and the goslings hurdled upon it. It readily sprouted after being fed down, but, of



Goslings hurdled by wire fencing two feet high in a field of Dwarf Essex Rape.

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course, did not furnish as much food, in proportion to the area, as when sown in drills and allowed to grow larger before feeding.

The young goslings eagerly ate the leaves of the Dwarf Essex rape, and made an excellent growth when hurdled upon it. It appears to be entitled to rank with tender grass and young growing grains as a fodder crop for goslings. This plant somewhat resembles kale in its habit of growth, although its leaves are less curled and have more resemblance to those of either the Swedish or French turnip. It has been extensively used in England as a fodder crop for sheep. It has the merit of growing quickly and resisting considerable frost, so that it is in good condition for feeding until the ground freezes. It can be sown as a "catch crop" after early potatoes, oats or rye. The seed is comparatively inexpensive and easily sown. It closely resembles turnip seed, and costs in the vicinity of fifteen cents per pound. Five pounds sown in drills, or ten pounds broadcast, is sufficient for an acre. When sown broadcast, a light harrow or a bush harrow will cover the seed sufficiently, and on fine, mellow soil, simply rolling the field would doubtless answer the purpose. For young goslings a sowing should be made quite early in the spring, and as soon as the plants are six inches high the goslings can be hurdled upon it. They will eat away the tender portion of the leaves, rejecting the stalks and crowns of the plants, unless confined for too long a time in one place. As soon as the goslings are removed to another place the rape plants begin immediately to grow a new supply of leaves, and thus the crop can be repeatedly "grazed" if the hurdling is properly done.

The accompanying illustration shows a flock of goslings confined upon a portion of a small field of Dwarf Essex rape, and shows plainly how the tender portions of the leaves are first eaten away. A wire fence two feet high, held in place by double pointed iron rods, made in the shape of the letter h, with the top portion much higher, is used for confining the goslings. The two points of the rod are about ten inches long, and are thrust into the ground, the point of the tall portion being thrust through the lower edge of the wire fencing, while the upper edge is held by a notch in the top of the rod. Of course different lengths of rods must be used for different widths of fencing.

Cabbages make excellent food for geese, and are especially adapted to winter use, particularly during the breeding season, when a greater variety of food is desired to stimulate the production of fertile eggs. Beets, turnips, carrots and potatoes will also prove acceptable, both raw and cooked, and in moderate quantities may be profitably fed. Geese are fond of apples, and when confined in an orchard, will consume the imperfect fruit which drops from day to day, as completely as pigs or sheep. In the absence of green food or roots a few apples, occasionally, during the winter, adds variety to the food and conduces to health and thrift.

From the foregoing it is evident that a great variety of foods suitable for the profitable feeding of geese may be grown, whenever desirable, upon the farms of the State. Stock feeders and dairymen are well aware that abundant June pasturage will generally produce a pound of flesh or a quart of milk easier, quicker and cheaper than can be accomplished in any other way. Goslings are rapacious feeders. and have the capacity to rapidly convert tender grass and forage crops into flesh, which commands a good price in the market, and is highly prized as an article of food. It has been abundantly demonstrated in repeated cattle, sheep and pig feeding experiments, that the *young animal* makes the most profitable use of food, because the appetite and power of digestion are good, and the proportion of food required to maintain life is smaller at that time, as compared with the total amount of food consumed, than is required later on. Hence every grower of goslings who would produce large birds for the least money, should see that his flock is well provided with an abundance of tender, nutritious pasturage, and promptly supplement any lack in that direction by a suitable supply of soiling crops.

REPORT OF THE METEOROLOGIST.

NATHANIEL HELME.

There has been no change in the usual work done by this department. The instruments in use are the same as those of a year ago. The quadruple register, which was saved from the fire, has recently been exchanged for a new anemometer, with weekly register, which, at the time of writing this report, has not been placed in position, but will be in the near future.

The Westerly Daily Tribune has been added to the list of newspapers publishing the monthly meteorological summary. The weekly crop reports during the growing season, and also the report of depth of snow on the ground each Monday afternoon, have been continued the same as last year. The tables which follow will show a summary of the weather for the year, as well as a comparison with that of former years, for which the record has been kept.

Summary for 1896.

Maximum temperature	93°	May 10th.
Minimum temperature	—11°	February 17th.
Range for the year	104°	
Mean temperature of the year	47.7°	
Highest monthly mean	70°	July.
Lowest monthly mean	23.4°	January.
Highest daily mean	81°	May 10th.
Lowest daily mean	—1°	January 6th and February 17th.

Precipitation.

Total for the year (rain and melted snow).	49.87	inches.	
Largest total for one month.............	7.44	"	September.
Least total for one month...............	1.48	"	April.
Greatest precipitation in 24 consecutive hours..................................	2.40	"	June 14th.
Total snowfall for the year..............	59	"	
Largest total for one month.............	19	"	March.
Least total for one month...............	5	"	November.

Weather.

Number of clear days in the year...........................	131
Number of fair days in the year............................	112
Number of cloudy days in the year.........................	123
Number of days with precipitation of .01 inch or more.......	109

Prevailing Winds.

N. E., 3 months; E., 1 month; S. W., 5 months; W., 3 months.

Atmospheric Pressure in Inches.

(Not corrected for temperature and elevation.)

Maximum pressure....................	30.61	inches.	December.
Minimum pressure....................	28.68	"	February.
Mean pressure.......................	29.84	"	

Summary, 1890, to 1896, Inclusive.

	1890.	1891.	1892.	1893.	1894.	1895.	1896.
Maximum temperature...	91°	94°	92°	92°	93°	95°	93°
Minimum temperature....	3°	5°	—1°	—6°	—9°	—7°	—11°
Mean temperature........	48.3°	49.4°	47.8°	46.5°	48.6°	48.2°	47.7°
Total precipitation, inches.	59.25	49.88	42.58	57.33	48.19	49.28	49.87
Number of clear days.....	99	116	147	126	110	128	131
Number of fair days......	143	154	116	130	130	114	112
Number of cloudy days...	123	95	103	109	125	123	123
Number of days with precipitation .01 in. or more.	120	83	89	131	114	108	109

Average mean temperature, 48.1°.

Average precipitation, 50.91 inches.

Comparing the weather conditions of each month with those of previous years, as was done in the last Annual Report, it is found that the January temperature and precipitation were both below the average, and it was the coldest January, with one exception (1893), since the record has been kept here. It was a month of fine winter weather, the heaviest precipitation falling on the 24th and 25th. With this exception the precipitation was generally light.

February mean temperature was very near the average. The minimum temperature of the month was the lowest of which we have any record here. On the 5th and 6th there was a fall of more than one inch in the atmospheric pressure within 24 hours. Between the 15th and 17th there was a drop of 51° in the temperature in 34 hours. The total precipitation was considerably above the average.

The precipitation for the month of March was also above the average. The excessive amount in this month and in February made the total for the first three months of the year more than 4½ inches greater than that of the same time in 1895.

The principal feature of the weather for April was the extreme temperature during the middle of the month, which was the highest for April since the record has been kept here. There were no severe storms during the month, and the precipitation was about one-third the average.

May was the warmest, and with one exception (May, 1891) the dryest, of which we have record. The maximum temperature (93°) was not exceeded in any month of the following summer, and the 10th of the month was the warmest day of the year. The rainfall was about one-half the average.

June was a wet and cool month, the precipitation being above and the mean temperature below the average. Two and four-tenths inches of rain fell on the 14th, which was nearly one-half of the total rainfall for the month.

While the rainfall and temperature of July were about the average, there was a large number of foggy days, and the rains, though not heavy, fell quite frequently, causing much damp weather, and delaying the gathering of the hay crop.

The first part of August was very warm. From the 7th to the 13th the maximum temperature ranged from 87° to 91°, and the mean from 75.5° to 78°. Notwithstanding this extreme heat, the mean temperature of the month was one-tenth of a degree less than that of August, 1895. The rainfall was a little below the average. Light frost was seen, on low lands, on the morning of the 20th.

September was a wet month, the rainfall being nearly twice the average for the month, and more than five times that of September, 1895. There were three thunder storms during the month that were more severe than any others during the summer. There was a heavy white frost on the morning of the 24th, on which date the thermometer registered 33°, the lowest for September of which we have any record here.

October temperature and rainfall were both below the average. Ice formed on the 26th of the month, on which date the lowest temperature (27°) was recorded. There were killing frosts on the 9th, 10th, 20th, 25th and 26th. Northeast gales prevailed on the 12th and 13th, but no damage was done by them here.

The mean temperature of November shows it to be the warmest of which we have record. The mean was 1.4° greater than that of November, 1895, which was considered a very warm month. The precipitation was a little less than the average. Five inches of snow fell on the 30th day of the month.

December was one of the coldest months of the year. The mean temperature was three-tenths of a degree less than that of February, in which month the lowest temperature of the year was recorded. The lowest temperature for December recorded here was 3°, but surrounding places reported a minimum of from 4° to 14° below zero on the 28th of the month. Most of the precipitation was in the form of snow, the total depth of which was 13 inches. There was an average depth of 5 inches on the ground at the end of the month. Heavy gales accompanied the two snow-storms of the month, causing it to drift considerably.

The first snow fell November 30th, and the last March 23d.

The last frost in the spring formed May 2d, and the first autumn frost August 20th; the first killing frost September 24th.

The mean relative humidity for each month of the year 1896 has been as follows:

January,	73.2	per cent.	July,	82.7	per cent.
February,	71.4	"	August,	79.8	"
March,	71.6	"	September,	83.	"
April,	69.6	"	October,	80.4	"
May,	72.1	"	November,	78.5	"
June,	77.2	"	December,	69.5	"

Average, 75.8 per cent.

Average for 1895, 77.6 per cent.

METEOROLOGICAL SUMMARY.

	JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.	
	1896.	1895.	1896.	1895.	1896.	1895.	1896.	1895.	1896.	1895.	1896.	1895.
Temperature.												
Maximum	42.°	52.°	50.°	47.°	61.°	52.°	85.°	68.°	93.°	91.°	86.°	95.°
Minimum	—10.°	3.°	—11.°	—7.°	5.°	15.°	22.°	23.°	32.°	30.°	43.°	46.°
Mean	23.4°	26.9°	28.1°	21.7°	30.6°	33.6°	46.4°	43.8°	58.4°	55.8°	63.8°	66.2°
Air pressure in inches												
Maximum	30.22	30.26	30.18	30.25	30.32	30.25	30.26	30.49	30.20	30.20	30.14	30.26
Minimum	29.40	29.05	28.68	28.49	29.39	29.03	29.40	29.15	29.53	29.35	29.36	29.62
Mean	29.93	29.81	29.62	29.64	29.70	29.75	29.91	29.81	29.83	29.85	29.79	29.89
Precipitation in inches												
Rain and melted snow	2.59	4.94	6.37	1.75	6.39	4.00	1.48	6.54	2.92	4.28	5.01	3.83
Snowfall	12.	16.	10.	18.50	19.	5.	Trace.	......	......	......	......	......
Weather.												
No. of clear days	12	9	10	13	12	13	13	11	11	9	10	6
No. of fair days	10	11	9	9	6	7	11	5	13	9	9	10
No. of cloudy days	9	11	10	6	13	11	6	14	7	13	11	14
No. of days with precipitation of .01 inch or more	8	14	11	6	10	14	6	12	9	10	6	8
Prevailing wind	N.E.	W.	W.	W.	W.	W.	E.	W.	S.W.	S.W.	S.W.	E.

METEOROLOGICAL SUMMARY.—CONTINUED.

	JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	1896.	1895.	1896.	1895.	1896.	1895.	1896.	1895.	1896.	1895.	1896.	1895.
Temperature.												
Maximum	89.°	87.°	91.°	87.°	84.°	94.°	77.°	70.°	70.°	72.°	55.°	57.°
Minimum	58.°	48.°	45.°	45.°	33.°	37.°	27.°	26.°	18.°	15.°	3.°	8.°
Mean	70.°	67.4°	69.8°	69.4°	60.7°	64.5°	48.2°	47.1°	45.8°	42.7°	28.2°	33.6°
Air pressure in inches.												
Maximum	30.22	30.02	30.08	30.09	30.17	30.14	30.29	30.40	30.48	30.44	30.61	30.56
Minimum	29.49	29.56	29.57	29.55	29.57	29.58	29.38	29.25	29.49	28.99	29.31	29.12
Mean	29.92	20.78	29.86	29.81	29.84	29.87	29.79	29.82	29.97	29.97	29.90	29.91
Precipitation in inches.												
Rain and melted snow	3.11	5.36	3.67	2.70	7.44	1.29	4.20	7.89	4.52	4.25	2.17	2.45
Snowfall	......	......	......	......	......	......	......	......	5.	Trace.	13.	6.
Weather.												
No. of clear days	6	9	13	11	9	15	10	15	9	9	16	8
No. of fair days	16	13	10	13	8	5	5	11	7	10	8	11
No. of cloudy days	9	9	8	7	13	10	16	5	14	11	7	12
No. of days with precipitation of .01 inch or more.	10	9	11	6	11	4	10	6	12	10	5	9
Prevailing wind	S.W.	S.W.	S.W.	S.W.	N.E.	S.W.	N.E.	W.	S.W.	S.W.	W.	N.

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Annual No. 8—Minnesota Farmers Institute, 1895, O. C. Gregg, Superintendent.

Fourth Biennial Report of the Kansas State Horticultural Society, Wm. H. Barnes, Acting Secretary.

Rhode Island Manual, 1895–'96, Chas. P. Bennett, Secretary of State.

Tenth and Eleventh Annual Reports of the Bureau of Animal Industry for the years 1893 and 1894, D. E. Salmon.

Report of the Kansas State Board of Agriculture, F. D. Coburn, Secretary.

Reports of the Results Obtained with Experimental Filters at the Pettaconset Pumping Station of the Providence Water Works, R. I. State Board of Health.

Royal Jersey Agricultural and Horticultural Society, Annual Report for 1895, Rev. A. Balleine, Island of Jersey.

Rapport Annuel de L'Analyste Officiel pour L'Annee Terminant le 25 Mars, 1895, Rev. A. Balleine, Island of Jersey.

Report on Agriculture and Forestry, New South Wales.

Forty-fourth Annual Report, 1895, of the Trustees of the Public Library of the City of Boston.

Forty-third Annual Report of the Secretary of the Massachusetts State Board of Agriculture, 1895.

Ninth Annual Report of the State Dairy Commissioner, Iowa, 1895, W. K. Boardman, Iowa State Dairy Commissioner.

Bulletin of the Geological Society of America, Vol. 7, pp. 349-362, pl. 16, Disintegration and Decomposition of Diabase at Medford, Mass., Geo. P. Merrill.

Transactions Massachusetts Horticultural Society for the year 1895, Parts I, II and III, Robt. Manning, Secretary.

Volumes of Reports of Maine State Board of Agriculture, B. Walker McKeen.

Proceedings of New York Farmers, Thos. Sturgis, Secretary.

The Gypsy Moth, Massachusetts State Board of Agriculture, Wm. R. Sessions, Secretary.

The Insects of New York, New York State Museum, J. A. Lintner, State Entomologist.

Second Annual Report of the Commissioner of Agriculture, Department of Agriculture, State of New York, Fred C. Schraub, Commissioner.

Oceanic Ichthyology (2 volumes), Smithsonian Institution.

Transactions of the Massachusetts Horticultural Society for the year 1896, Part I, Robert Manning, Secretary.

Second Biennial Report of the West Virginia State Board of Agriculture, 1893-'94.

Thirty-eighth Annual Report of the Secretary of the Maine State Board of Agriculture for the year 1895, B. Walker McKeen, Secretary.

Report of the Commissioner of Agriculture for the year 1867, Wm. S. Alexander.

Report of the Kansas State Board of Agriculture for the quarter ending September 30, 1896, F. D. Coburn, Secretary.

Report of the Commissioner of Education, 1893-'94, Vol. 2.

Report of the Superintendent of Farmers' Institutes of the Province of Ontario, 1895–'96, F. W. Hodson.

Botanical Opportunity, Address of Wm. Trelease, Botanical Society of America.

First Report of the State Dairy Bureau of California, 1895–'96.

Wisconsin Farmers' Institutes—A Hand-Book of Agriculture—Bulletin No. 10, Geo. McKerrow, Superintendent.

Numerous reports and publications of the U. S. Government Department of Agriculture and other departments have been received, as well as all bulletins and reports from all the Experiment Stations in the United States and several foreign countries.

Organisacao Fazenda de Santa Rosa, Estudos Experimentaes, 1893–1894, Instituto Fluminense d'Agricultura, Rio de Janerio.

SEEDS.

Vegetable and flower seeds, W. Atlee Burpee & Co.

Seven packages of grass and forage plant seeds, F. Lamson Scribner, U. S. Department of Agriculture.

One half pound Danish Island oats, W. Atlee Burpee & Co.

One half pound Clydesdale oats, Peter Henderson & Co.

One half pound White Maine oats, Henry A. Dreer.

MISCELLANEOUS.

One bag ucainit, German Kali Works.

Nine bags Thomas Phosphate Powder, H. J. Baker & Bro.

One set Transplanters, F. Richards.

EXCHANGES.

Copies of the following agricultural and other papers have been regularly received at this office, where they are kept on file for reference:

Agricultural Epitomist, Indianapolis, Ind.
American Agriculturist, New York, N. Y.
American Cultivator, Boston, Mass.
American Fancier, Johnstown, N. Y.
American Grange Bulletin and Scientific Farmer, Cincinnati, Ohio.
American Horse Breeder, Boston and New York.
American Poultry Advocate, Syracuse, N. Y.
American Stock Keeper, Boston, Mass.
Baltimore Weekly Sun, Baltimore, Md.
California Cultivator, Los Angeles, Cal.
California Poultry Tribune, San Diego, Cal.
Colorado Poultry Journal, Denver, Colo.
Connecticut Farmer, Hartford, Conn.
Elgin Dairy Report, Elgin, Ill.
Fancier's Star, Jacksonville, Ill.
Farmer's Guide, Huntington, Ind.
Farmer's Magazine, Springfield, Ill.
Farm, Field and Fireside, Chicago, Ill.
Farming, Toronto, Canada.
Farm News, Springfield, Ohio.
Farm Poultry, Boston, Mass.
Feathered World, London, England.
Fruit, Dunkirk, N. Y.

Grange Visitor, Lansing, Mich.
Hoard's Dairyman, Fort Atkinson, Wis.
Holstein Friesian Register, Boston, Mass.
Home and Farm, Louisville, Ken.
Homestead, Des Moines, Iowa.
Hope Valley Free Press, Hope Valley, R. I.
Indiana Farmer, Indianapolis, Ind.
Industrial American, Lexington, Ky.
Inter-State Poultryman, Tiffin, Ohio.
Louisiana Planter, New Orleans, La.
Massachusetts Ploughman, Boston, Mass.
Midland Poultry Journal, Kansas City, Mo.
Mirror and Farmer, Manchester, N. H.
Montana Fruit Grower, Missoula, Mont.
National Provisioner, New York, N. Y.
National Stockman and Farmer, Pittsburgh, Pa.
Nebraska Farmer, Lincoln, Neb.
New England Fancier, Yarmouthport, Mass.
New England Farmer, Boston, Mass.
Our Grange Homes, Boston, Mass.
Ohio Poultry Journal, Dayton, Ohio.
Pacific Coast Dairyman, Tacoma, Wash.
Pomona Herald, Pascoag, R. I.
Poultry Herald, St. Paul, Minn.
Poultry Keeper, Parkesburg, Pa.
Practical Dairyman, Chatham, N. Y.
Practical Farmer, Philadelphia, Penn.
Practical Ohio Farmer, Cleveland, Ohio.
Public Ledger, Philadelphia, Pa.
Reliable Poultry Journal, Quincy, Ill.
Rural New Yorker, New York, N. Y.
Southern Cultivator and Dixie Farmer, Atlanta, Ga.
Southern Fancier, Atlanta, Ga.
Southern Planter, Richmond, Va.
Southwestern Farm and American Horticulturist, Wichita, Kansas.

Sugar Beet, Philadelphia, Pa.
The Fancier, Graham, North Carolina.
Tri-State Farm News, Toledo, Ohio.
Toledo News, Toledo, Ohio.
Vermont Farmer's Advocate, Burlington, Vt.
Wallace's Farmer and Dairyman, Ames, Iowa.
Western Farmer and Stockman, Sioux City, Iowa.
Western Garden and Poultry Journal, Des Moines, Iowa.
Western Poultry Journal, Cedar Rapids, Iowa.

LIST OF STATION PUBLICATIONS FROM DATE OF ORGANIZATION TO 1897.

Year.	Number.	Title.	Pages.
*1888.	First Annual Report.	Report of Board of Managers	27
*1889.	Bull. 1.	Organization of Experiment Station	12
* "	" 2.	The Farm, Historical, Physical and Geological Description	16
* "	" 3.	Stock Feeding	40
* "	" 4.	Bee Keeping. Establishment of the Apiary	32
* "	" 5.	Potatoes. Meteorological Summary	10
"	Second Annual Report.	Report of the Director. Reprints of Bulletins 1 to 4, inclusive, and brief reports of the heads of Divisions	124
*1890.	Bull. 6.	Milk Fever, or Parturient Apoplexy in Cows	24
* "	" 7.	Catalogue of Fruits. Meteorological Summary. Report of the Apiarist	40
* "	" 8.	Soils and Fertilizers	34
* "	" 9.	Experiments in Apiculture	24
* "	Third Annual Report.	Report of Director. Crops and Field Experiments. Co-operative Field Experiments with Fertilizers on Indian Corn. Experiments with Potatoes (varieties). Experiments with Bordeaux Mixture as a Preventive of the Potato Blight. Trials of Varieties of Fruits and Vegetables. Reports of Divisions	196
*1891.	Bull. 10.	Mixed Foods in Cases of Faulty Appetite in Horses and Neat Stock: Including Notice of Patented and Proprietary Foods. Sore Shoulders in Horses	8
* "	" 11.	The State Fertilizer Law as it is and as it might be. Commercial Valuations of Fertilizer Stock. Analyses of Commercial Fertilizers, State Inspection, 1891. Analyses of Miscellaneous Materials. Meteorological Summary	20
* "	" 12.	Further Analyses of Commercial Fertilizers Collected under the State Inspection, 1891, with Comments	12

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*Out of print.

Year.	Number.	Title.	Pages.
1891.	Bull. 13.	Concluded List of Fertilizer Analyses, State Inspection, 1891. Analyses of Miscellaneous Materials	18
* "	" 14.	Notes on the Potato Scab and Bordeaux Mixture as a Preventive of Potato Scab and of Potato Blight. Notes on Transplanting Onions	18
*1892.		Fourth Annual Report. Report of Director. Field and Plot Experiments. Co-operative Field Experiments with Fertilizers on Indian Corn. Brief Reports of Divisions	118
* "	Bull. 15.	Treatment of Loose Smut of Oats. Fungicides and Insecticides. Black Rot of the Grape, and Apple Scab. Codling Moth, Cankerworm and Plum Curculio	25
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"	" 17.	Analyses of Commercial Fertilizers, State Inspection, 1892	8
"	" 18.	Analyses of Commercial Fertilizers, State Inspection, 1892. A Word of Caution in the Purchase of Wood Ashes	8
"	" 19.	Concluded List of Fertilizer Analyses, with Summaries and Comments	12
*1892.	" 20.	The Production of Capons. Experiments in Caponizing. Prices of Capons, Broilers, Roasters and Fowls in Boston and New York Markets. When to Make Capons, the Time to Sell, and How to Prepare for Market. Caponizing Tools, and How to Perform the Operation	42
* "		Fifth Annual Report. Report of Director. Winter and Spring Application of Ashes to Newly Seeded Meadow. Shrinkage in Curing Field Corn. Tests of Varieties of Oats. Jensen Hot Water Treatment for Prevention of Smut of Oats. Fertilizer Experiments with Oats. Trials of Different Forms of Phosphates. Trials of Muskmelons. Leguminous Crops. Co-operative Field Experiments on Indian Corn. Potato Scab. Trial of Lawn Grasses. Remedies for the Rose-Bug. Crossbreeding of Poultry. Reports of Divisions.	140

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“	Sixth Annual Report.	Report of Director. Rotation of Crops. Co-operative Field Experiments. On the Occasional Ill Effect of Sulfate of Ammonia as a Manure, and the Use of Air-slacked Lime in Overcoming the Same. On the Effect of Air-slacked Lime Used in Connection with Certain Forms of Organic Nitrogen. Applying Liquid Manure with Hydrant Water. New Varieties of Strawberries. Seed Examination. Experiments with Turkeys. Diseases of Turkeys. Reports of Divisions	165
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“ Leaflets.	Circular Bull. 1.	Plan of Soil Test. Co-operative Test of Varieties of Vegetable and Field Seeds.	
	“ 2.	Request for Information Regarding “Black Head” of Turkeys.	
	“ 3.	List of Experiments in Progress.	
1894.	Seventh Annual Report.	Report of Director. Field Experiments. Soil Test with Fertilizers and Plants. Growth of Various Plants upon an Upland Acid Soil Before and After Liming. On the Substitution of Soda for, and Its Value in Connection with, Potash. On the Fungous Parasites of the Apple and Pear. Infectious Disease of Turkeys. Report of Divisions.	135
1895.	Bull. 31.	Some Special Orchard Treatment of the Apple, Pear and Quince	18

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"	" 33.	Fertilizers. Potatoes. Potato Scab	52
"	" 34.	Analyses of Fertilizers. Home-Mixed Fertilizers	48
"	" 35.	Garden Seeds	40
"	Eighth Annual Report.	Report of Director. Relative Growth of Common Sorrel and Clover upon an Upland Acid Soil Before and After Liming. Soil Tests with Plants and Fertilizers. On the Growth of Various Plants upon an Upland Acid Soil Before and After Liming. On the Substitution of Soda for, and Its Value in Connection with, Potash. The Recognition of the Acidity of Upland Soils and Its Bearing upon Agricultural Practice. Ammonium Thiocyanate as an Impurity in Ammonium Sulfate. Heating Greenhouses: trials of different kinds of piping. Experiments with Indian Corn. Forage Plants. Leguminous Plants Grown without Nitrogen and with Different Quantities. Three Seasons' Experiments Cross-Breeding of Geese. Reports of Divisions	202
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"	Ninth Annual Report.	Report of Treasurer. Report of Director. Oysters in Point Judith Pond. Report of Horticultural Division. Test of Garden Seeds. The Fairy Ring Disease of Carnations. The Carnation Rust. Report of Chemical Division. On the Substitution of Soda for, and Its Value in Connection with, Potash. Further Observations upon the Growth of Various Plants upon an Acid Upland Soil, Limed and Unlimed. Continued Observations for the Purpose of Determining in How Far the Results Secured in a Soil Test, with a Given Plant, are Applicable to Others. Further Observations upon the Growth of Barley upon an Acid Upland Soil, Limed and Unlimed. *(Con. p. 380).*	

Date.	Number.	Title.	Pages.
1896.	Ninth Annual Report.	Observations for the Purpose of Ascertaining if a Lack of Lime is More or Less General in Rhode Island Soils. Further Observations for the Purpose of Determining Whether the Beneficial Action of Lime upon the Soil of the Experiment Station Farm is Due, to any Extent, to Its Neutralizing Action. The Army Worm in Rhode Island. Trial of Phosphates. Further Tests of Northern and Home Grown Seed Potatoes. Report of Poultry Division. Report of Meteorologist. Donations. List of Station Publications, from Date of Organization. to 1897.. ..	228

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AND

ANNUAL REPORT

OF THE

RHODE ISLAND AGRICULTURAL EXPERIMENT STATION,

FOR THE

YEAR 1896.

PROVIDENCE:
E. L. FREEMAN & SONS, STATE PRINTERS.
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